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OVER THE LAND.

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THE DISTRIBUTION OF RAINFALL OVER THE LAND.

INTRODUCTION.

The moisture in the atmosphere has never been so thoroughly studied as some other elements of meteorology, notably temperature and pressure. Yet it plays no small part in the economy of the world. Water is the great variable in the atmosphere. Unlike the two chief constituents, nitrogen and oxygen, it is found not merely in different quantities, but also in different physical states, in different places, and indeed at the same place at different times. It is a sort of life-blood of the atmosphere, penetrating all parts of it. As vapour, it lessens the density of the atmosphere; as cloud, it absorbs the solar rays, and thus diffuses the Sun's heat through the upper atmosphere, instead of allowing it to pass on to the Earth's surface; as rain, it clears the air of dust and other impurities. Its rapid and protean changes under the influence of varying temperatures involve great transformations of energy, and are the main source of the enormous power displayed in all the great commotions in the atmosphere. It has also a conservative influence in diminishing the difference of temperature between day and night by the heat absorbed and given out in its alternate evaporation and condensation, and by the shielding action of clouds to solar and terrestrial radiation.

Temperature, wind, sunshine, and moisture are the chief factors in applied climatology. This is true not only for plants, but for animals and man. Temperature and sunshine are favourable enough for plant-life in the Sahara, but moisture is lacking. This scarcity of moisture, however, makes the Sahara a healthy region for human beings, in spite of its excessive temperatures, compared with the equatorial low lands, where the temperatures are less extreme, but the moisture is very abundant. These equatorial conditions, however, favour vegetable growth. The scarcity of moisture in the air in the cold arctic winter permits man to live healthily enough, and he is depressed by the lack of sunlight rather than by deficiency of moisture or of heat. For man, as for other animals and for plants, there is a maximum and a minimum of moisture, as of other meteorological factors, in excess or defect of which it is noxious, and there is also an optimum condition which is most favourable to his development.

Hence it is most important to people of very different interests to have an exact knowledge of the distribution of moisture. But the estimation of moisture is not so easy a matter as that of temperature or pressure. The actual gravimetric determinations are very delicate and comparatively slow operations. The ordinary methods are to deduce the pressure and quantity of water-vapour in the atmosphere from the effect of evaporation in lowering the temperature of a wetted thermometer bulb. The ordinary method of placing dry and wet bulbs in a louvred screen invalidates the certainty of the estimates, for the wind influences evaporation, and this factor is rarely taken into account. Only in recent years has the use of aspiration or sling psychrometers been adopted, and the observations are made at few places and for too short a period to be mapped. The use of condensation hygrometers is subject to the same criticism. Hair hygrometers are also employed, but, on the whole, they give good qualitative rather than exact quantitative records.

The determination of the lowering of temperature due to evaporation, or of the temperature of the condensation point, commonly called the dew-point, does not permit the calculation of the total quantity of water in the air, but only of the water-vapour. The liquid and solid water are not accounted for. The floating particles are visible as haze, fog, mist, or cloud, and are carefully observed at all meteorological stations. But their measurement affords qualitative rather than quantitative values. The personal experiences of the author in hygrometric records led him to abandon an attempt to map the distribution of relative humidity. The comparatibility of the records in different countries employing different reduction-tables, and even the comparatibility of records at the same place with the same reduction-tables under different atmospheric conditions, are very doubtful matters.

The water that actually falls from the atmosphere to the ground can be exactly measured, and the distribution of this precipitation or rainfall is the subject of this paper and the accompanying maps. It is true that no rain-gauge, still less no snow-gauge, is perfect, but the percentages of error can be estimated and the figures obtained may be considered as fairly satisfactory. The measurement of rainfall is the simplest of all meteorological observations, when the necessary but not irksome precautions are taken. The importance of a knowledge of rainfall in practical affairs has led to the establishment of very many rainfall stations. The total number on the surface of the globe is probably over 25,000; but, while this number is very large, the uneven distribution of the stations, and the shortness of the periods for which observations are available in many regions, are drawbacks. Rainfall also varies very greatly within small areas, especially in mountainous regions, and it can be safely affirmed that in no hilly country are the rainfall stations numerous enough to allow more than an approximation to the exact trend of the lines of equal rainfall (isohyets) being shown on a large map. The scale of most climatic maps, however, is so small that in the lower hilly portion of Europe the data are almost sufficient to enable accurate lines to be traced on the small scale maps employed; but this is not the case for the more mountainous regions, such as the Alps. Rainfall maps require data from more stations than the temperature or pressure maps, wherein the variation due to altitude are eliminated. For instance, in India, about 100 stations sufficed to give the data necessary for drawing the isobars and isotherms shown on the maps in Dr. Buchan's *Challenger* Report; but, for rainfall, nearly 1100 stations were used, and still the isohyetal lines are merely approximate in many mountain regions.

Cloud or rainfall maps, therefore, are those at our disposal for studying the distribution of water in the atmosphere, but the latter are much more precise, and are of much greater value in practical affairs. The rainfall maps might approximately serve for cloud maps, if properly interpreted, but the reverse is hardly true. As a rule, the rainfall maps, especially when studied with temperature maps, give us a very clear and accurate idea of the distribution of water in all its forms in the atmosphere near the surface of the Earth. There are a few exceptions, the most important being the cases of the south-west coast of Africa and the west coast of Peru, where rain seldom falls, yet where the air is almost saturated every morning.

The first good annual rainfall map of the world was published by Prof. Loomis, of Yale University, in 1882 (see references to literature at end). This map was used by Dr. Hann in his classical *Atlas der Meteorologie*. A revision of the same map, by Dr. A. Buchan, was published in the *Scottish Geographical Magazine* in 1887, from which Sir John Murray calculated the 'Total Annual Rainfall on the Land of the Globe, and the Relation of Rainfall to the Annual Discharge of Rivers.' Since my maps were drawn, and much of this essay was in manuscript, Dr. Supan, the distinguished editor of *Petermanns Mitteilungen*, has published not merely a new annual rainfall map of the world, but four seasonal ones, and another showing variations of rainfall. I have been able to revise, and in some parts to slightly amend, my maps by using the data for the few stations in Dr. Supan's tables which I had not in my collection. A note of data, supplementary to those of Dr. Supan, will be found at the end of this paper.

It is not enough to know the mean annual value of the rainfall of a place. That of many places in Spain and North-West Africa is the same as that in many parts of China, where the mean annual temperatures also agree. But the seasonal distribution of rain is quite different in the two regions. In Spain the summers are dry; in China they are wet. This is true in districts much less remote from each other than Spain and China. The Cape Peninsula has a dry summer, while Natal has a wet one, yet the annual rainfalls of two places may approximate.

		Height.	Min.	Max.	Year.
		feet.	ins.	ins.	ins.
West	Royal Observatory, Cape Town (10 years)	40	0·41 Jan.	4·72 May	27·95
	Rondebusch (10 years)	100	0·50 Jan.	9·31 June	44·34
East	East London (10 years)	33	1·03 June	3·06 Nov.	25·52
	Durban (6 years)	260	0·35 June	6·12 Oct.	42·46

In South Africa, however, there is a higher rainfall more uniformly distributed throughout the year in the east than in the west, with a marked summer maximum in the east and a winter one in the west, as a glance at the monthly maps shows.

The practical bearing of this will be obvious if we consider for a moment the typical cultivated plants in these regions. The vine and olive are typical of Spain, and tea of China. The vine flourishes at the Cape, and tea is cultivated in Natal. The grape needs a dry, sunny, late summer to ripen, the tea shrub requires the summer to be wet and sunny, that its leaves may develop rapidly. So for many other plants the seasonal distribution of rain has an important influence on their distribution.

Another one of many cases may be cited. In problems of water-supply for large and small towns, and the compensation reservoirs often required in connection therewith, the question of seasonal distribution of rainfall is very important. For such purposes a knowledge of the actual amount is essential, and not merely information as to the season of the year when most rain falls.

The dry and rainy seasons, however, do not coincide with the astronomical ones, and four maps showing the mean monthly distribution of rainfall, while of great value, are insufficient. Three months are too long a period to illustrate the seasonal peculiarities of rainfall, especially for the spring and autumn of temperate areas, and for the intermediate times between dry and wet seasons in lands of low latitudes.

The Indian Meteorological authorities find it quite unsatisfactory to adopt the ordinary astronomical seasonal division for India, and accordingly have divided the year into four seasons of unequal lengths. These are January and February, the season of cold weather rains of Upper India; March to May, the hot season; June to October, the rainy season; and lastly, November and December, the season of north-east monsoon rains of South India. Even this is not quite satisfactory; for we find in the Quetta region October and November the driest months, one of which is thus reckoned to the rainy season of India. If Ceylon be added to India, we find at Colombo on the west coast, February, and also July, August, and September dry months, while April and May, and again October and November, are wet; but at Trincomalee,

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means. The isohyets were then drawn on this transparent paper while fixed to the map underneath whose colours and figures were visible below, and shadowed forth the relative values of the means of each station. In most cases it was found of great help when drawing the isohyets to put the tracing-paper over a map, on the same scale, which had the relief of the land strongly shown either by hachures or by contours.

(4) The complete lack of numerical values for many parts of the world could not, of course, be made up. Brief jottings of the period and characteristics of the rainy season were put on the tracings, and helped to determine where the isohyet was to pass. For these jottings Dr. Hann's classical work on 'Klimatologie' was mainly used, first in the earlier edition and latterly in the new one.

Except for Western Europe, the United States of America, Algeria, and South Africa, the present maps are original, based on data the sources of which are indicated at the end of this paper. Dr. Buchan allowed me to make use of his manuscript maps of the British Isles and of South Africa. Dr. Angot was good enough to send me manuscript copies and advanced proofs of his maps of Central and South-Western Europe and of Algeria. Lastly, the Weather Bureau's rainfall maps of the United States of America were copied. After my own maps were ready, Dr. Hamberg's maps of Sweden, and Mr. Tillo's maps of Russia were received, and led me to modify some of the lines previously drawn. My own manuscript maps for India, South-Eastern Australia, and the continuation of Dr. Angot's maps eastwards and southwards, and of the United States maps to Mexico and Canada were also used. These maps will appear on a larger scale than is used here in Bartholomew's 'Physical Atlas,' vol. iii., 'Atlas of Meteorology,' which is now in the press.

The isohyets were originally drawn on maps with scales differing according to the number and closeness of the stations for the particular region.

Europe, Canada, Australia south of the tropic and east of 135° E. were drawn on scales between 1 : 6,000,000 and 1 : 10,000,000.

India, 1 : 4,000,000.
East and West Indies and Mexico about 1 : 16,000,000.
Eastern Asia and South America, about 1 : 20,000,000.
Africa 1 : 22,500,000.
North America and North Asia on a Mercator whose equatorial scale is 1 : 65,000,000.

All the lines were then drawn on uncoloured Mercator maps 1 : 65,000,000, and joined up. From these maps those now published have been reduced.

DESCRIPTION OF MAPS.

Introductory.—When describing the distribution of rainfall in each month it will be necessary to divide the world into several large areas, which should, as far as possible, be homologous with each other. The most convenient morphological element to choose for this purpose is the low-pressure area, or cyclonic area, whose limits are lines of maximum barometric pressure.*

The baric surface of the globe shows two ridges of higher pressure which girdle the Earth between the tropics and 40° north and south latitude respectively. They may be termed the *sub-tropical baric ridges*, or crests of maximum atmospheric pressure. These divide the world into three regions. The baric trough between the two sub-tropical baric ridges may be called the *sub-equatorial baric trough, or depression*, whose line of minimum atmospheric pressure roughly follows the line of the equator. As the winds blow steadily from the north and south sub-tropical baric ridges to the central minimum line of this sub-equatorial depression all the year round, we shall call all this, mainly inter-tropical, expanse, that of the *constant or steady or trade-wind system*. The baric troughs north and south of the northern and southern sub-tropical baric ridges are the expanses of the *north and south temperate depressions* or *storm-wind systems*.

In the southern hemisphere, where this temperate trough is deepest, the baric surface probably rises to a region of slightly higher pressure round the south pole; but this need not be further discussed here, as it does not influence the regions whose rainfall is dealt with in this paper.

In the northern hemisphere this polar area of higher pressure always exists.

All these baric ridges and hollows vary in position, intensity, and extent with the position of the sun.

There is another series of baric heights and hollows running roughly north and south, and changing from continent to ocean with the seasons.

---

* All references to temperature, pressure, and winds in this paper are derived from the "Report on Atmospheric Circulation," by Dr. A. Buchan, in the '*Challenger* Reports—Physics and Chemistry,' vol. ii. (Edinburgh, London, and Dublin, 1889), unless another source is specially indicated. This monograph is occasionally referred to simply as the '*Challenger* Report.'

Had we been dealing with the rainfall of the whole of the Earth's surface, it might have been advisable to have chosen as morphological units the areas enclosed by lines of maximum pressure. But as only the rainfall over the land surface is discussed in the present paper, it will be preferable to draw the north and south boundaries of our areas through the great oceans, and to use the lines of maximum pressure running east and west as the other limits.

The morphological peculiarities of the pressure systems of the different months, which occasionally slightly mask this simple distribution of pressure areas, will be briefly pointed out in succeeding sections.

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JANUARY.

ividing lines between the steady and stormy wind systems in this month ›roximately lat. 40° N. or more over the northern continents, and lat. 30° N. .e oceans in the northern hemisphere, and 35° S. in the southern hemisphere.

Northern Storm-Wind System.

ıeral.—The general characteristics of this system in January are steep ature and pressure gradients, due to the excessive cold in the north of the ›nts. The temperatures over the land are low, and those over the sea are .nd consequently the pressures over the continents are high, and those over › are low. The minimum isotherms and the maximum isobars are convex ıe land, and concave over the oceans when looked at from the south. The ııgh-pressure area forms a baric ridge, which crosses the arctic area close to :thern shores of North America. The temperature is highest over the east oceans and the west of the continents, and this is more marked in the ›an Atlantic regions than in the North American Pacific regions. The winds ·om the continental high-pressure area to the oceanic low-pressure area, and, ›equence of this, the air is passing from colder to warmer regions, and little re is condensed from it except where the low pressures over the north and ıcific and Atlantic oceans approach the coasts. These coastal regions are the influence of oceanic winds, and receive the relatively warmer air and ·lentiful water vapour from the oceans, which vapour is condensed as it passes ›lder regions. The rainfall of the northern storm-wind area in January is, re, coastal and mainly west coastal.

is coastal rainfall is very heavy, especially in the mountainous regions. The storms are both numerous and heavy. The steepness of the cyclonic pres- ·adients and the violence of the winds are a reflection of the general steepness thermal and baric surfaces at this season. The high winds make the ty of air passing any place very large, and neutralise the effect of the low ·ature which keeps the total amount of water-vapour very low.

rth American Storm-Wind Area.—The high-pressure area over North ›a has a triangular shape, with its apex pointing northward, the reverse of the itself. The Pacific and North Atlantic low-pressure areas respectively the north-west and north-east sides of this high-pressure area. The prevailing therefore, are between west and south-west in the west, and between west and n the east. The south-west winds strike the west coast as far south as San sco, and from here northwards to beyond Sitka. The western slopes of the mountains receive more than 100 mm. (4 inches) of rain, and much of this strip has more than twice this precipitation. East of the coastal ranges ain falls. Along the axis of the continent is a great region—20° broad at ., and widening outwards to the north—which is almost symmetrically ed on both sides of the north and south line of maximum pressure, and s less than 25 mm. (1 inch) of rain.

The temperature gradients along the east coast are very steep, and the moisture drawn in from the Atlantic Ocean or from the Gulf of Mexico is rapidly condensed. The prevalent winds are north-westerly in the north-east of the continent, and the South Greenland coast is the only one that derives rain from them. But the storms which pass over the eastern region, in greatest frequency along the St. Lawrence valley, suck in winds from the coast, while their centres still lie west from it. Some of these storms have their origin on the plains of Texas, and we must consider the lower Mississippi region in that of the western storm-area during this period of the year.*

The region receiving more than 50 mm. (2 inches) of rain in January lies between the east coast and a line drawn from the north-west shores of the Gulf of Mexico to Sault Ste. Marie, and thence to the strait of Belle Isle. The narrow Atlantic coastal plain receives more than 100 mm. (4 inches) of rain, and the Gulf plain and lower Mississippi are as heavily moistened as far north as Nashville, and almost to Cairo. The higher temperature and greater amount of water-vapour in the air drawn from the Gulf, the flatness of the land, and the greater temperature gradients, explain the wide expansion of the 4-inch rainfall region here compared with that on the east coast. In some parts of this area, south of the track of the storm centres from Texas, more than 150 mm. (6 inches) of rain fall.

The rainfall diminishes steadily from a region not far distant from the coast to the interior, both from the Gulf and from the Atlantic coasts. Some figures may be cited.

Going northwards up the Mississippi valley the rainfalls are as follows: New Orleans, 130 mm. (5·1 inches); Vicksburg, 135 mm. (5·3 inches); Memphis, 140 mm. (5·5 inches); Cairo, 94 mm. (3·7 inches); St. Louis, 56 mm. (2·2 inches); Davenport, 43 mm. (1·7 inch); St. Paul, 25 mm. (1·0 inch); Winnipeg, 20 mm. (0·8 inch). From Halifax, N.S., westward near the 45th parallel, we have a similar succession of figures: Halifax, 147 mm. (5·8 inches); Montreal, 89 mm. (3·5 inches); Marquette, 53 mm. (2·1 inches); Duluth, 28 mm. (1·1 inch); Bismarck, 15 mm. (0·6 inch).

The presence of the great lakes modifies the climatic condition in their vicinity. Heavier rainfalls (over 100 mm.) are experienced in the north-west of both Lakes Huron and Michigan, while regions with less than 50 mm. (2 inches) exist to the east of the southern-west of these lakes, and south of Lakes Erie and Ontario.

Eurasian Storm-Wind Area.—The high-pressure area over Eurasia is also roughly triangular in shape, pointed to the north, but the apex is drawn out towards the east, to the north of the North Pacific depression, and also the south-western region is drawn over the Atlantic south of the great Iceland depression. The winds in the west are between south and west; those in the east are between west and north.

As the centre of low pressure lies between Iceland and the south of Greenland, the winds strike the south coast of Iceland, which receives heavy rains. In Western Europe the cyclonic storms bring abundant rain to the coasts from the north of Portugal to the Lofoden islands. Both in the Iberian and Scandinavian peninsulas we find very great and rapid changes in the rainfall immediately east of the western slopes of the mountains of the west coast. In some parts of the west the rain is over 150 mm. (6 inches), whereas east of the mountains it is less than one-sixth of this. For instance, in the west at Bergen the rainfall is 176 mm. (6·9 inches), and at Molde 139 mm. (5·5 inches), but east of the mountains it is less than 25 mm. (1 inch) over a considerable area.

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* 'Rainfall of the United States.' Weather Bureau, Bulletin D. Washington, 1897. Hereafter cited as "Bulletin D."

This can be seen quite as well in the British Isles. The western highlands of Scotland receive over 300 mm. (12 inches) in some districts, within 40 miles (65 km.) of the shores of Moray Firth, round which less than 50 mm. (2 inches) fall.

The higher districts in France are fairly well watered, but most of the lower ground of the interior has less than 50 mm. (2 inches).

The lofty mountains of the interior of Europe do not stand out in bold relief as rainy regions. The rainfall gradually diminishes over the plains from west to east, and, in spite of the fact that the storms are numerous and intense, the rainfall is nowhere very heavy. The lowness of the temperature keeps the quantity of water in the atmosphere low, and most of this is precipitated on the western hills, or is gradually condensed over the plains as it passes westward over a thermal gradient rapidly falling to the east. East of 25° E. there are few regions which have a rainfall over 25 mm. (1 inch). This approximately agrees with the limit of the isotherm of −4° C. (25° Fahr.).

With this Eurasian storm-wind region we must consider the Mediterranean lands. The Mediterranean at this season is within the cyclonic storm region of the northern hemisphere, and much of the rain that falls comes with the depressions that pass across it. These storms reach the extreme east of the sea. The Mediterranean region is one of varying temperatures and pressures corresponding to its varied surface of water and land. In January there is relatively low pressure over the sea itself compared to that over the south of Europe, where high pressure conditions prevail, especially over the three southern peninsulas. There are great differences of rainfall to be found here. In the east and centre of Spain less than 25 mm. (1 inch) fall, whereas the Algerian coasts receive more than 200 mm. (8 inches). (Ain Draham, 278 mm. = 10·9 inches.)

The western coasts here also receive more than the east coasts. The contrast is well seen when we compare these dry regions of Eastern Spain with the west of Syria, where 188 mm. (7·4 inches) are precipitated at Beirut, and as many as 160 mm. (6·3 inches) at Jerusalem, the maximum monthly precipitation for these places. In the Adriatic and Black Seas this is also graphically shown by the colouring on the map.

In the east of Asia the isotherm of −4° C. (25° Fahr.) is also roughly the boundary of the vast region receiving less than 25 mm. (1 inch) of rain. Even the coastal regions, where more than this falls, are very limited in extent, viz. South-East Kamchatka, Western Japan, and East Korea.

The *western* coasts of Japan receive heavy rains. The winds here are from north to west, and the temperature and the quantity of water-vapour both rapidly increase as they pass from the cold continent over the warmer Japanese sea. They are chilled, and the vapour falls as abundant snow and rain, when they are deflected by the mountains of Japan, whose western slopes are moistened, while the eastern ones receive little rain. The fall at Niigata is 208 mm. (8·2 inches) (nine years' mean), whereas at Tokyo for the same nine years it was only 41 mm. (1·6 inch).

SOUTHERN STORM-WIND SYSTEM.

The sun, the heat equator, and the wind systems of the globe are near their southern limit in January, and the austral westerly storm winds do not reach either Africa or Australia. Their effect is felt in the south-west of New Zealand and of South America. In the former the rainfall is over 200 mm. (8 inches), in the latter over 100 mm. (4 inches) in January. The eastern districts of these regions have a much lower rainfall than the western ones. The broader South American land, protected on the west by much higher mountains, is very dry in the west, where less than 25 mm. (1 inch) falls.

THE STEADY-WIND SYSTEM OF LOW LATITUDES.

Over the continents the thermal equator is far south of the geographical one in January, and the sun is in the zenith at noon between 22° 58′ S. and 17° 14′ S. The sub-equatorial line of minimum pressure lies a little farther to the north, but well south of the equator. In consequence of this southern position of these lines, in sympathy with that of the sun, the equatorial rain-belt is found south of the equator, and approximately lies between it and the tropic of Capricorn. Few inland places north of the equator receive more than 25 mm. (1 inch) of rain, whereas such dry regions are of very limited extent south of the line.

In studying the rainfall of this region it is important to notice that both the thermal maximum and the baric minimum lines cross the continents from north-west to south-east. The greatest heat and the lowest pressure lie to the south and east of the inter-tropical parts of the continents, except in Australia, where they are in the north-west.

In the regions of the north-east trade winds the ranges of mountains of eastern coastal lands uplift the wind and cause a heavy precipitation on their windward slopes. The north-east of Formosa, and the east of Indo-China, and of the Philippines, Borneo, and Ceylon; the north-east of the West Indian Islands and of Central America, and the Guiana coast all receive heavy rains.

The regions of excessive rainfall between the equator and the tropic of Capricorn are the Malay Archipelago and North Australia, North-West Madagascar, and the Nyasa region of Africa, and probably also the southern portion of the Congo basin and the Amazon basin in South America. These are the rainy regions of the thermal equatorial belt, where the land is flat; or the rainy regions of the southern hemisphere, where the north-west monsoon winds are deflected upwards by mountain barriers.

The changes of the wind from north-east to north-west on crossing the equator and its effect on the rainfall are clearly seen in several regions. In Borneo the east coastal region north of the equator has more than 400 mm. (16 inches) of rain in January, and so has the north coast of Celebes. The *west* coast of Celebes, south of the equator, is the rainiest, also with over 400 mm. of rain. Arnhem Land, in Australia, and the north-west coast of Madagascar are also very rainy ones for the same reason. Probably a more accurate knowledge of the distribution of rain will show this more obviously in other regions.

If the land masses south of the equator have the effect of intensifying the heat in the south in the southern summer, and drawing the north-east trade farther across the line than over the oceans, their relationship to the water mass also modifies this simplest general change by many minor and local ones. Many instances can be given. The Gulf of Carpentaria keeps the eastern half of North Australia cooler and at higher pressure than the western half, and the normal north-west monsoon is deflected into a northerly wind, which makes the southern shores of the gulf wetter than the western ones, except round Cape York, where the north-west wind strikes the land. The great area of Southern Africa causes elongated high temperature and low-pressure areas whose axes are nearer the east than the west coast. The inflowing winds, north of 20° S. on the east side, retain their easterly trend, and the north-east trade wind continues to blow, as an intensified north-east wind, south of the equator. Hence we find the Nyasa region the rainiest in Africa at this season. There are no data for the region lying to the west of Nyasa, but this probably receives very heavy rains in January, as is indicated on the map.

When we examine the west coast of Africa we find no north-west trades, and

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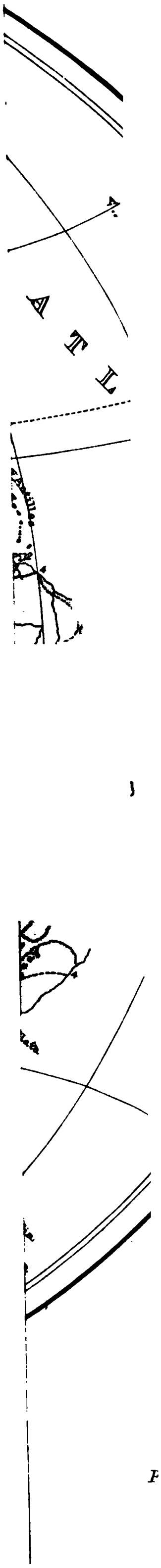

'en the north-east are not developed to any extent south of Sierra Leone. The influence of the low pressures over the South African plateau is seen in the weakening and westing of the winds and lessening of the rainfalls, which reach a minimum at this season. The western projection of the North African plateau causes a permanent relatively warmer and less dense belt of air to rest over the Sudan compared with that over the Gulf of Guinea, and the winds blow from the a inland all the year. They are south-west winds, which we may regard as analogous to south-west monsoon, only permanent. The high pressures to the north restrict their influence at this season, and the rainfall is comparatively low.

There is a notable strip of coast between Cape Three-Points and Wydah, where the rainfall is very low, which may be partly explained by the winds blowing parallel to or off the shore for much of the year. Dr. Hann has called attention to the up-welling of cold water off these coasts, and its effect in cooling the air, which we can imagine lying in a denser mass which turns the lighter moisture-bearing air-currents to the side and upwards. These are likely to be cooled where they reach the outer margin of this cooler region, partly by this upward deflection. This may account for the records of exceptionally heavy rains at Grand Bassam to the west of Cape Three-Points, 110 mm. (4·3 inches) in January, compared with 1 mm. (0·04 inch) at Elmina and 9 mm. (0·4 inch) at Accra to the east. The nnual rainfalls of these three stations are: Grand Bassam, 6312 mm. (248 inches); mina, 782 mm. (31 inches); Accra, 740 mm. (29 inches); and point to the persistence of this condition. It must be noted that we have only one year's rainfall record from Grand Bassam, and three from Elmina, and five from Accra. Observations at and between the two stations will be of exceptional value in defining the limits of this low rainfall and indicating its causes.

The special form and position of South America make the rainfall distribution of peculiar interest, and also render it very difficult to draw the isohyetal lines in the interior, for which hardly any accurate data exist. While Africa gains little or no rain from the north-east trades, except on the east coast south of the equator, as we have just seen, South America gains much of its rainfall from these winds. In South America the region of highest temperature and of lowest pressure also lies in the east and south of the Amazon. Hence the north-east winds, after passing over the oceans, penetrate the Northern Amazon basin, and get turned round to north and north-west winds, which distribute the moisture over a vast area. But the air over this region is steadily up-welling at this season of the year, and we may look for the sources of the rain partly in the great evaporation taking place all over this intensely heated area, and partly to the moisture brought and distributed by the trade winds. The waters of the Amazon, Orinoco, and upper Parana-Paraguay rivers passing from this area at this season partly represent the water brought to it by the winds, and partly that derived from melting snows previously deposited. But much water is evaporated over the whole region, and then precipitated again, to be once more vaporised and condensed.

In the north-east of the Brazilian Highlands the winds blow parallel to the north-north-east coast, where it is dry, and they are drawn almost easterly to the south-south-east coast, where they do form a rainy strip, which, however, as far as observations exist, appears to be very narrow. The rainfall at Pernambuco on this coast, where the wind is due east on an average eighteen days every January, is 111 mm. (4·4 inches). At Victoria, a little inland, it is 85 mm. (3·3 inches), and at Isabel only 36 mm. (1·4 inch); the two last on a mean of seven years.

The south-eastern quarter of the low-pressure region is also a rainy one. From Minas Geraes southwards the precipitation is a maximum at most stations. Here the land is higher, and any winds from the south-east are intensified by the low-pressure attraction, and forced up to considerable elevations. The coastal winds, however, are not all from the south-east, and at Rio de Janeiro, where a quarter of the January winds are north-west and only two-fifths between east and south, there is a narrow strip of coast with a lower rainfall than farther inland. But much of the precipitation is water evaporated from the surface, for calms prevail in many parts. For instance, at Santo Paulo, where the rainfall in January is 269 mm. (10·6 inches), there are twenty-two calm days in the average January, but what winds do blow come from north-west to south-east through north.

The south-east trades are sucked over the middle Paraguay-Parana basin, and deposit much rain there. At this season their effect is felt furthest west, and Salta, Tucuman, and other stations at the foot of the Andes receive their maximum rainfall in January, as well as the lands nearer the coast.

FEBRUARY.

The pressure-ridges and hollows are distributed very similarly to those of January. None of them are so marked as those of January, except the regions of high pressure over the oceans.

NORTHERN STORM-WIND SYSTEM.

General.—The cold over North-East Siberia is not so excessive, and both temperature and pressure gradients are on the whole less steep in February than in January. The general features of pressure distribution remain the same. The winds still blow out from the interior of the continents to the oceans, except along the west coast of the former, and the rainfall remains coastal. The maps show that the rainfall of February is distinctly lower than that of January over most of this area. This is not due to the difference in the length of the month, for in drawing the isohyetal lines this has been allowed for (see p. 6). The explanation probably lies in the relative less intensity of the storms, and in the slighter temperature gradient. The temperature of stations on the west coast does not greatly differ in January and February, as the latter month is that in which the ocean waters, which have so great an influence in determining the temperature of coastal stations, have the lowest temperature. Hence the maximum amount of water vapour possible in the atmosphere cannot be very different in January and February. The storms are not so intense, and the winds less violent; hence the amount of water vapour blown inland will not be so great in February as in January, and this air is not so rapidly cooled, as the temperature gradients are not so steep.

At Bergen the temperature in January is 1°·1 C. (34°·0 Fahr.), and the rainfall 176 mm. (6·9 inches); in February the temperature is 0°·2 C. (32°·3), and the rainfall 141 mm. (5·6 inches). At St. Petersburg, on the other hand, the January temperature is −8°·2 C. (17°·2 Fahr.), and the rainfall 22 mm. (0·9 inch), compared with the February temperature of −8°·6 C. (16°·5 Fahr.), and rainfall of 21 mm. (0·8 inch). At Tobolsk the February temperature, −15°·8 C. (3°·5 Fahr.), is markedly above that of January, −16°·7 C. (1°·9 Fahr.), whereas the rainfall is only 14 mm. (0·6 inch) in February, compared with 17 mm. (0·7 inch) in January.

North American Storm-Wind Area.—The high-pressure area over North America has undergone opposite changes over land and over sea. The continental part has weakened, that lying west of the Californian coast has become more intense, and the North Pacific depression has weakened. The rainfall is much less all along the United States coast, but from Vancouver Island to Sitka, where the winds between the North Pacific high and low pressure areas strike the coast, the rainfall is slightly higher in February than in January, if allowance be made for the different lengths of the two months. The rainy strip is narrower over the whole region, and the area of land receiving more than 25 mm. (1 inch) of rain is at a maximum in January. Sitka, January, 187 mm. (7·4 inches); February, 183 mm. (7·2 inches). Neah Bay, Washington, January, 312 mm. (12·3 inches); February, 297 mm. (11·7 inches). San Francisco, January, 127 mm. (5·0 inches); February, 89 mm. (3·5 inches).

The east coast rainfall is also lower, and the strip of land with 50 mm. (2 inches) of rainfall slightly narrower than in January. The coastal strips, with a precipitation over 100 mm. (4 inches), are reduced to a small area at Cape Hatteras and in the south-east of Nova Scotia. The areas south of Lakes Erie and Ontario, where less than 50 mm. falls, have increased; but over most of the continent the rainfall is low.

Eurasian Storm-Wind Area.—The Azores (North Atlantic sub-tropical) high-pressure area has extended westward over the Atlantic, and like that off the Californian coast, is almost severed from that over the adjacent continent, which has diminished in intensity. The Icelandic (North Atlantic) low-pressure area is weaker and broader, and it is more drawn out over the seas north of Europe. The winds striking the coast are weaker, and here again we find a much lower rainfall in February than in January, even along the coasts, as a comparison of the January and February columns of the Norwegian rainfall tables shows at a glance, even when one-tenth is added to the February figures to make them comparable with those of January.*

The rainfall is also less over the whole Mediterranean area, and this is most noticeable in the north of Africa and on the Syrian coasts.

The rainfall of the Far East preserves the same characteristics in January and February, but here again the rainfall is lower in February.

The contrast between the east and west coasts of Japan is not so well marked in February as in January. Japan is more in the anticyclonic area in February, and the pressure at Niigata rises from 762 to 763 mm. (30·008 to 30·049 inches), while the precipitation sinks from 208 to 112 mm. (8·2 to 4·4 inches). The proportion of winds blowing from between west and north is also less. The south coast, however, is an exception to the general rule, for it receives a little more rain in February than in January: Tokyo, for instance, has a January rainfall of 41 mm. (1·6 inch), but a February one of 52 mm. (2·0 inches); Nagasaki, 66 mm. (2·6 inches) in January, 76 mm. (3·0 inches) in February. At Tokyo the pressure has risen 2·5 mm. (0·010 inch), but at Nagasaki it has fallen 10·4 mm. (0·041 inch).

SOUTHERN STORM-WIND SYSTEM.

Southern Africa and Australia are still practically north of the track of the brave west winds. In South America there is a slight increase in the rainfall at most of the west and south coast stations, but it is not enough to make any perceptible alteration on the isohyets for the two months.

STEADY-WIND SYSTEM OF LOW LATITUDES.

The sun is zenithal at midday at 16° 57′ S. at the beginning, and at 7° 46′ S. at the end of the month. The thermal equator has also moved appreciably further north, and a small area with more than 32°·2 C. (90° Fahr.) is now found north as well as south of the equator in Africa. The sub-equatorial baric trough is also slightly further north, and crosses the continent with a more marked north-west south-east trend than in January.

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* Nedbör-höiden i Norge. Norsk Teknisk Tidsskrift, 1893.

The leading characteristics of rainfall distribution remain the same as in January, but there are a number of minor modifications which must be noticed.

American Area.—The pressure has risen over South America near the southern tropic. The baric trough north of it indicated by the isobar of 756·8 mm. (29·8 inches) in January has disappeared, while the isobar flanking the coast has hardly altered in position or value, except that the line of 759·5 mm. (29·9 inches) lies considerably to the east of the west coast, and crosses the continent about 35° S. There is, therefore, a much flatter gradient in the Upper Amazon and Madeira basins, and the few available figures show a diminution of rainfall at this period. In the lower half of the Amazon basin, on the other hand, the rain is slightly heavier, but not enough to make any perceptible change in the position of the isohyets. The rainfall of the Guiana coast is slightly lower in February than in January.

The south-east trades, however, are weakened, for the South Atlantic high-pressure area is lower and the Brazilian low-pressure area is higher than in January. The rainfall in this region is probably lower. Unfortunately, we have only two stations really inland, one on the Paranahyba with one year's rainfall, one at Santa Anna do Sobradinho, on the São Francisco, with three and a half years' returns. The former had a precipitation of 219 mm. (8·6 inches) in January, only 110 mm. (4·5 inches) in February; the latter 77 mm. (3·0 inches) in January, and only 40 mm. (1·6 inch) in February.

The east coastal precipitation in February at Pernambuco and Bahia is almost the same as that for January, allowance being made for the shortness of February.

But in dealing with South American rainfall north of the Tropic of Capricorn it is not possible to do more than make rough guesses at the distribution of rainfall except at a very few coastal stations.

African Area.—When we turn to Africa we find the rainy areas pushed a little to the north, but otherwise very little modified, except in the east and round the Bight of Benin. The low-pressure area is no longer close to the east coast, but the deepest trough runs from the Niger to Madagascar. The hill-slopes facing the Gulf of Guinea have more rain precipitated on them. We find that 45 per cent. of the winds at Akassa come from the west, north-west, north, north-east or east in January, but in February only 17 per cent. come from these directions, and the number of calm days increases from eight in January to fifteen in February. The eastern coastal plain from Gazaland to Zanzibar receives less rain, but the Nyasa region of heavy precipitation is wetter in February.

Asia-Australasian Area.—In India there is a slight increase in the rainfall of the Ganges delta, owing to an increase of winds from the warm Gulf of Bengal. The following table shows this, and also that the southerly winds and heavier rains do not penetrate far inland:—*

	Mean wind direction.		Mean rainfall in inches.		Mean rainfall in millimètres.	
	Jan.	Feb.	Jan.	Feb.	Jan.	Feb.
			in.	in.	mm.	mm.
Chittagong ...	N. 26° W.	N. 43° W.	0.44	1·23	11·2	31·2
Calcutta	N. 36° W.	S. 89° W.	0·41	1·20	10·4	30·5
Saugor island ...	N. 6° W.	S. 52° W.	0·28	1·10	7·1	27·9
Cuttack	N. 28° E.	S. 7° W.	0·36	0·52	9·1	13·2
Dhubri	N. 26° W.	S. 16° W.	0·43	0·56	10·9	14·2
Patna	N. 84° W.	N. 80° W.	0·68	0·52	17·3	13·2
Allahabad	N. 40° W.	N. 63° W.	0·76	0·46	19·3	11·7

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* Selected from the *Indian Weather Review*, Annual Summary. Calcutta, 1896.

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The rainfall in North-West India and in East Beluchistan is also relatively ightly higher in February than in January. It is due to cold weather storms, which usually occur in the early part of the year.

In the south-eastern islands, between Asia and Australia, the maximum rainfall ccurs at much fewer stations in February than in January. The east coast of Borneo is very much less wet, and all over Celebes the precipitation is relatively ess in February. The Philippines and Formosa receive more rain in the north nd east, but practically the same in the south and west, and the China coast is lso slightly wetter where exposed to the winds.

MARCH.

The sub-tropical high-pressure ridges have not altered greatly in position, but hey have changed considerably in their height and in their gradients. The o ern high-pressure areas have diminished in intensity and in extent over the nd; while the southern ones have increased over the ocean and spread across he land so that a high-pressure system nowhere less than 761 mm. (29·95 inches) asses round the Earth between 30° and 35° S.

NORTHERN STORM-WIND SYSTEM.

The isotherms are now much further apart and more nearly parallel to the quator, for the Siberian and North American cold areas have greatly diminished n intensity. The interiors of the continents are still very dry, but the rainfall, while of the coastal type, reaches farther inland than in February, and even than n January. The resistance to the passage of the winds is less owing to the ecrease of pressure over the land. The initial temperature of the moisture-laden ir is slightly higher, but the storms are fewer and the winds are weaker, so hat the coastal rainfall is lower on the west coasts.

North American Area.—The pressure area over 764·5 mm. (30·1 inches) is now north of the Great Lakes, and extends beyond the cold pole almost to the geographical one. The baric ridge connecting the American and Asiatic high-pressure reas is more marked north of the American continent than heretofore. The North Pacific depression is shallow, with weaker gradients, and the temperature has not isen much on the coast, while it has increased greatly farther inland; so that, as we might expect, the west coastal rainfall of the United States and Canada is lightly lower. The following table shows the temperature and rainfall at coastal and slightly inland stations off the west coast of North America in February and rch, both reduced to one-twelfth of a year in the case of the rainfall:—

	Temperature in degrees Fahr.			Rainfall in inches ($\frac{1}{12}$ year).		
	Feb.	Mar.	M.–F.	Feb.	March.	M.–F.
ka	32·9	35·6	2·7	7·0	5·2	–1·8
Canby, Oregon (temp.) Astoria, Oregon (rain) ...	43·8	45·5	1·7	9·2	9·0	–0·2
Portland, Oregon	41·7	46·7	5·0	6·4	5·4	–1·0
Red Bluff, Cal.	49·4	54·3	4·9	3·8	2·8	–1·0
San Francisco, Cal. ...	51·9	53·4	1·5	3·8	3.0	–0·8
Sacrimento, Cal.	50·3	54·6	4·3	3·0	2·8	–0·2

It is still true for the British Columbia and Alaskan fjord coast lands that the rain is either pouring, or has just left off pouring, or is just beginning to pour again; but it is not so heavy as in the two months we have already discussed.

In the east of North America, on the other hand, the temperature is much higher in March than in February, and especially inland. The rainfall in both months has been reduced to that for one-twelfth of a year.

TEMPERATURE AND RAINFALL AT COASTAL AND INLAND STATIONS IN FEBRUARY AND MARCH IN THE EAST OF NORTH AMERICA.

Temperature in degrees Fahr.

	Halifax, N.S.	Montreal.	Winnipeg.	Boston.	Chicago.	Washington.	Cairo.	Charleston.	Vicksburg, Miss.	New Orleans.
February	23·1	17·5	0·7	36·3	29·3	36·3	40·8	53·3	53·5	58·4
March	28·8	25·5	11·6	42·2	35·4	42·2	46·7	57·8	59·6	62·6
M. – F. ...	5·7	8·0	10·9	5·9	6·1	5·9	5·9	4·5	6·1	4·2

Rainfall in Inches in one-twelfth of a Year.

	Halifax, N.S.	Montreal.	Winnipeg.	Boston.	Chicago.	Washington.	Cairo.	Charleston.	Vicksburg, Miss.	New Orleans.
February	5·3	3·1	1·0	3·8	2·4	3·3	4·2	3·1	5·3	4·8
March	5·0	3·3	1·1	4·0	2·4	3·8	3·7	3·4	5·4	5·2
M. – F. ...	–0·3	0·2	0·1	0·2	0·0	0·5	–0·5	0·3	0·1	0·4

The change of rainfall at the inland stations in the East is small. At the coast the increase of rainfall is very slight, but on the whole the isohyetal lines have moved slightly to the west in March. The weaker baric gradients and winds and the relatively more rapidly increasing warmth of the interior, practically counterbalance any advantage derived from the higher temperature and greater possible amount of water vapour in the air blown from the coast.

Eurasian Area.—The development of the Atlantic high-pressure system north of the Tropic of Cancer into a separate high-pressure area, whose crown lies about 30° N. and 30° W., and the breaking up of the Atlantic low-pressure area into two parts, one between Iceland and South Greenland and the other north of the White sea, are the chief pressure changes. But they are important. This sub-tropical North Atlantic baric mount and the western sub-arctic North Atlantic baric hollow are the great determinants of the coastal winds of Europe; as the one or the other increases in intensity and area, so the weather changes. The effect of the decrease in intensity of the sub-arctic depression is to weaken the winds in the north-west of Europe.

The isotherms in the west of Eurasia no longer run from north-north-west to south-south-east, but almost from west-north-west to east-south-east, so the inflowing air is not so soon chilled. The coastal rain, owing to the weaker winds, is lower; that of the interior, owing to the less steep temperature gradients, is slightly higher far inland. At Bergen in March the temperature is 1°·6 C. (34°·9 Fahr.), or 1° C. (2°·6 Fahr.) above February, and the rainfall is only 109 mm. (4·3 inches) or 32 mm. (1·3 inch) below February, or 45 mm. (1·8 inch) if we reckon both months in twelfths of a year. At St. Petersburg the March temperature is −4°·3 C. (24°·2 Fahr.), or 4°·3 C. (7°·7 Fahr.) above February, and the precipitation is 22·6 mm. (0·9 inch) in March compared with 20·7 mm. (0·8 inch) in February, *i.e.* the same average amount per twenty-four hours. But St. Petersburg lies in the Baltic dry area, which we shall discuss presently. At Tobolsk we find the March temperature 7°·6 C. (18°·3 Fahr.), or 8°·2 C. (14°·8 Fahr.) above that of February, and the March precipitation 17·1 mm. (0·7 inch), or a little over 1·5 mm. (0·06 inch) above February, allowing for differences in the month's length. A section across Europe farther south shows this even better. At Valencia, south-west of Ireland, the temperature is 7°·5 C. (45°·5 Fahr.) in February, and 7°·9 C. (46°·3 Fahr.) in March, and the rainfall is 134 mm. (5·3 inches) in February and 108 mm. (4·3 inches) in March, while at Warsaw the temperature is in February −2°·8 C. (26°·9 Fahr.), and March 1°·7 C. (33°·9 Fahr.), and the rainfall 27·6 mm. (1·1 inch) in February and 34·3 mm. (1·4 inch) in March, 4·2 mm. (0·17 inch) more in March when both values are reduced to one-twelfth of a year.

The rainfall differs from that of January and February in being much less heavy on the coasts and better distributed inland. One marked feature south of the Baltic is the disappearance of districts with less than 25 mm. (1 inch) of rain in the lee of the mountains. This may be connected with a greater proportion of east winds than in the earlier months.

The Baltic region east of the Scandinavian watershed is still one of low rainfall, under 25 mm. (1 inch), and, as we have seen at St. Petersburg, the precipitation is the same in February and March. The western mountains are quite high enough to precipitate most of the water in the air at all seasons of the year, and this area is always one with a relatively low precipitation.

The high-pressure system in Central and Eastern Asia has become less intense, but it is beginning to extend its limits eastwards over the Pacific coast. The west coastal rainfall of Japan has become less marked, and the south coastal rainfall has grown in quantity.

SOUTHERLY STORM-WIND SYSTEM.

Tasmania, the south-west of Victoria, and of West Australia, and of South Africa begin to receive rains from the west, but in March there are but slight traces of this, and the south-east of Australia and Cape Colony are still much wetter than the south-west. In South America the northern parts of the fjord coast of Chile begin to have greater precipitation, which is further developed as the winter progresses. In the region of Argentina south of the Plate Estuary, the rainfall is a little heavier than in January or February.

THE STEADY-WIND SYSTEM OF LOW LATITUDES.

This month the overhead sun at noon passes from 7° 23′ S. to 4° 21′ N.

American Area.—The isobars now run almost west and east across inter-tropical America, and the minimum line of the sub-equatorial baric trough almost coincides with the equator. The rain falls most heavily on and south of the equator, and is beginning to increase again on the Guiana coast after the February minimum.

The Paranahyba and middle São Francisco valleys receive much more rain than in February. At Santa Anna do Sobradinho 148 mm. (5·8 inches) fall on an average of three years, and this is almost double that of the next wettest month, January (78 mm., or 3·1 inches), which in its turn is almost twice as wet as February (40 mm., or 1·6 inch), the third wettest month. At Alto Paranahyba, February (110 mm., or 4·3 inches) was drier than either January (219 mm., or 8·6 inches) or March (233 mm., or 9·2 inches), which had much the same rainfall. February may, therefore, be the brief and slightly marked autumn dry season of a region on the border of the equatorial area, with two dry and two wet seasons every year.

African Area.—The low-pressure area is now spread out over the heart of Africa from north of the Tropic of Cancer to south of Lake Tanganyika, and winds blow into it from all sides. The distribution of rain, like that of pressure, is much more symmetrical with respect to the coasts of the continent. North-west, north and north-east of the northern part of the low-pressure area the inflowing winds bring no rain, and north of 10° N. less than 25 mm. (1 inch) falls. Between 7° N. and 20° S. over 100 mm. (4 inches) of rain falls, but south of this line the climate is drier, except on the south-east coast, where the south-east trades are uplifted. In the centre are regions where the precipitation is more than 200 mm. (8 inches). The south-east corner is the Nyasa rainy region of earlier months, but now much less wet, corresponding to an increase in the pressure. The south-west of this rainy region is on the Angola highlands, where the pressure gradient is steepest. The intermediate Congo region is also probably very wet. The north-west wet region curves inland round the Gulf of Guinea, from the Congo mouth beyond the westernmost distributary of the Niger. Calms and south winds have increased, and prevail five days out of six at Akassa this month, and in this region the warm moist air over the Gulf of Guinea is sucked in towards the heart of the low-pressure area over the Sudan, and the moisture is deposited as it rises over the plateau.

The corresponding north-east rainy region is not so well marked. At Fort Smith in British East Africa the mean of three years gives a precipitation of 249 mm. (9·8 inches), and one of two years at Machakos 198 mm. (7·8 inches), which differs only 2½ mm., or a tenth of an inch, from the mean at Fort Smith for the same two years. The same two years (1894–95) at Kibwezi give a mean of 157 mm. (6·2 inches), and on the east of Kilimanjaro, at Marangu, one year's observation gave a probable amount of 336 mm. (over 13 inches), but at Moschi, a little further west, but on the southern slope of the mountain, only 114 mm. (4½ inches) in 1895. As the height of the two stations is the same, the one must be sheltered compared to the other, or else the rainfall observations at one or the other are not exact.

The narrow low coastal strip south of the Congo is a region of lower rainfall. Along this part of the West African coast the temperature still rises rapidly from the sea-shore to the interior, when corrected for height, so that the moisture is not condensed until it reaches a considerable elevation.

	Latitude.	Height in		Actual temperature.	Reduced to sea-level.
		metres.	feet.		
St. Paul de Loanda...	48° 49′ S.	61	194	25°·6 C. (78°·0 F.)	25°·6 C. (78°·0 F.)
Malange	49° 33′ S.	1173	3850	20°·8 C. (69°·4 F.)	28°·7 C. (83°·7 F.)

Hence the air at about 1200 feet as far inland as Malange has the same temperature as that at the sea-level at the coast; the isohyet of 4 inches (100 mm.) must be drawn within that orographical contour line.

The north-west monsoon winds no longer reach Madagascar, where the heavy

C

ns fall on the east coast, and the protected south-west receives less than 50 mm. inches). On the north-west coast the rainfall is at least half that of January in ne districts.

Asia-Australasian Area.—The rains are heavier in March in Western Turkestan r the mountains and in the mountains themselves. The temperature conditions very unstable, as Prof. Hann has pointed out ('Klimatologie,' vol. iii. p. 192), d the upwelling air has its moisture condensed. In Herat (Hann, 'Klimatologie,' . iii. p. 112) much rain falls in spring, and the figures for Kabul (three years' an) show us that the maximum rainfall of 151 mm. (5·9 inches) falls in March. e rains also continue in March in the Quetta region, but in diminished quantity.

The changes noted in February in the north-east of India have developed in rch. The Khasi hills and the Upper Assam valley show districts with a rainfall of r 150 mm. (6 inches), and all the delta district is much better watered. A small pression exists immediately south of the tropic and west of the Bay of Bengal, d all around it from 12·5 to 25 mm. (half to 1 inch) of rain falls. In the south districts with more than 12·5 mm. rain have increased, but in the south-west, d not in the south-east as was the case in January. Ceylon has its now normal ing type of rain, heavy in the south-west hill-slopes, less in the north-east of the ins, but the contrasts are not yet very great.

In the south-east of Asia, the rainfall north of the equator has increased, and ly in Burma and in the lee of the southern Anam mountains is the rainfall less 25 mm. (1 inch). On the other hand, the precipitation in tropical Australia s greatly diminished.

APRIL.

The southern sub-tropical high-pressure ridge is now near 30° S., and is even more m and well marked than in March. The northern sub-tropical baric ridge is, the other hand, well marked over the oceans, where it rises to over 764·5 mm. ·10 inches) in the Atlantic, and over 770 mm. (30·30 inches) in the Pacific . It is not well marked over the continents, and forms the rim of a baric w developed near the 40th parallel both in America and in Europe.

NORTHERN STORM-WIND SYSTEM.

The low-pressure areas over the North Pacific and the North Atlantic oceans ve decreased in area and intensity, and the high-pressure areas over both conents have also been displaced to the northwards and diminished in extent. The ssure gradients are now much weaker. The southward trend of the isotherms m west to east across the continents is much less marked. The depressions in warmer sub-tropical regions of North America and Europe are marked features he month.

The rainfall ceases to be coastal, and commences to be continental in character. re moisture can be carried in the atmosphere owing to the increase of temperature, the same range of cooling produces a much greater precipitation. The higher ture ensures the melting of the snow, and an increased vapour-supply not y from the snowfields, but from all land with surface water. The snowless lowds, too, near the snowy mountains become moister as they receive water from m, and in this way also the supply of water-vapour in the air is increased.

North American Area.—The most noticeable feature we have seen is the northrd movement of the isotherms and isobars, and the rainfall maps show a similar gration of the isohyets. The North American areas with less than 25 mm. inch) of rain in April are distinctly separated into a northern region, which passes south of the Canadian frontier only in the heart of the continent, and a southern region in the central plateau region of the western Cordilleras as far north as Great Salt Lake.

In spite of the higher temperature and the greater water-vapour carrying capacity of the air, there is a decrease in the coastal rainfall both in the west and in the east, which must be explained by the diminution and weakening of the storm winds in April and the disappearance of a falling temperature gradient from the coast to the interior. In the south-west regions this temperature gradient is a rising one, and this has much to do with the increase of the dryness of this part of the North American Cordilleran system at this season.

Over other parts of temperate North America the precipitation has increased. The local supply of vapour, as well as the local instability of temperature and pressure, have increased. The Gulf area receiving over 100 mm. (4 inches) of rain has slightly receded in the north, but on the whole is not much altered, owing to the insucking of air from the Gulf to the low-pressure hollow in the south of the Cordilleras, which we have noticed as a peculiarity of the pressure distribution of April.

Eurasian Area.—For the European region there are some very marked pressure features which have a determining influence on the distribution of precipitation in April.

In the north the double hollows of the North Atlantic low-pressure area remain. That north of Scandinavia is weaker, but still draws winds over the Norwegian seas, which, however, bring less rain to the north-west coasts of the peninsula. The south-west depression in this area is also less well marked, but it has moved southwards more than 5°, so that its centre lies west of the north of Ireland. This affects South Greenland, Iceland, the southern half of Scandinavia, the British Isles, and the north-west of France. The south-west of Greenland and the south-east of Iceland no longer receive such strong winds and heavy precipitation. South-Western Scandinavia, the North Sea lands, the British Isles, and North-West France have fewer winds from the Atlantic, and more from the easterly quarter than in most months of the year. The rainfall is low, and in some districts of this region is a minimum in April. In the British Isles the east coast rainfall slightly increases, while the west coasts are very much less wet than in previous months, for the places with more than 100 mm. (4 inches) of rain are now exceptional.

The Atlantic high-pressure area round 30° N. is no longer joined by any baric ridge to the high-pressure region which still exists in Asia, but a low-pressure hollow has formed over the Alpine area, and embraces Sardinia, South Italy, and most of the Balkan peninsula. The rainfall is heavier and more evenly distributed over all this region in April.

The extreme east of the Mediterranean region has become drier, and the northern boundaries of the steady wind area now approach it.

The great bulk of Asia is still very dry. In the north-east the pressure gradients are still from the continent to the ocean, but are very weak. The rainfall is very low in this region.

In Japan the rainfall distinctly increases from north to south, and from April onwards the winds from the southerly quarter, and therefore flowing over the Kuro Shiwo, come laden with warm moisture. We have here a beginning of summer conditions, which are discussed later.

SOUTHERLY STORM-WIND SYSTEM.

In South America we find the west coast rainfall increasing, and that in the lee of the mountains diminishing, as the winter conditions begin to develop. But we also have in the latitude of La Plata an increase of rainfall with a development of storm conditions.

In South Africa the decrease of the south-east rainfall with the passing to the north of the trade-wind area is even more marked than the beginning of the summer rains in the Cape peninsula and the south-west. In the south-east, in March most of the land received over 100 mm. (4 inches) of rain, but in April only very small areas have as much as 75 mm. (3 inches), and the position of the 50 mm. (2 inch) isohyets for March is taken by the 25 mm. (1 inch) isohyets in April. On the other hand, the Cape peninsula has a precipitation of over 50 mm. (2 inches) in April, double that of March.

The same phenomena are observable in Australia. The March 25 mm. (1 inch) line in the south-west is replaced by the 50 mm. (2 inch) line as far east as King George Sound. Southern Victoria now has a rainfall of over 50 mm. (2 inches).

Nearly all New Zealand lies within high-pressure area in April, and the rainfall is less, and at Hokitika on the west coast reaches its minimum.

STEADY-WIND SYSTEM.

The sun is overhead at noon at 4° 44′ N. on April 1, and at 14° 56′ N. on April 30.

The sub-equatorial baric trough lies very little, if anything, to the north of the equator this month, except in Central Africa; but, while it can still be traced across the Indian ocean just north of the line, a well-marked depression has formed to the north over the Tropic of Cancer in India. This sub-tropical depression intensifies and extends its bounds as the northern summer advances, and rules the weather of the southern and eastern regions of Asia for several months.

American Area.—The equatorial rain-belt has moved northwards, but Mexico still remains in the dry region. The rainfall in the south of the Mosquito coast is now heavy. The districts with less than 25 mm. (1 inch) rainfall have greatly diminished in the north of South America, where the region with more than 100 mm. (4 inches) has extended.

The region of excessive precipitation, over 300 mm. (12 inches), has increased at the mouth of the Amazon. In the north-west part of the basin south of the equator the rainfall has diminished. We find evidence for this in the one year's rainfall record of Iquitos—March, 311 mm. (12·2 inches); April, 165 mm. (6·5 inches)—and in the observations of rainy days on the Beni in 12° S., where there were 19 in March and 7 in April and in May. The north-east coast of Brazil and the south-east as far south as Bahia are heavily watered in April, but again, as in February, the interior is much drier, and at Santa Anna do Sobradinho we find the dry winter conditions already fully developed. Paraguay and Southern Brazil have a rainfall of over 100 mm. (4 inches).

African Area.—The high temperature and low-pressure areas lie over the Sudan and distinctly north of the equator. The band of rainfall over 100 mm. (4 inches) has moved north to about 10° N., and extends to less than 15° S.; and over the region between 20° and 25° S., less than 25 mm. (1 inch) fall.

The region with over 200 mm. (8 inches) has moved north-westwards, and the coasts of the Bight of Biafra have a precipitation of over 300 mm. (12 inches). Only a patch of high ground to the south of Nyasa receives abundant precipitation. The coast opposite Zanzibar and Pemba must be added to the area with a rainfall over 200 mm. Heavy rains probably fall over the dense forest land west of Lake Albert and over the Middle Congo. The limits of heavy rains will have to be modified when statistics are available for this region, as at present they are diagrammatic approximations. In Uganda the rainfall is near the 200 mm. (8 inches) limit. Mr. Scott Elliot * gives the mean of eight years' observations which he obtained from the records when he visited Natete, Mengo, at 195 mm. (7·66 inches) in ten days. Two years' observations near Tanganyika, 45° 29′ E., gave 232 mm. (9·10 inches).

In Somaliland rain falls both on the north and south coasts (Hann, 'Klimatologie,' ii. pp. 128, 129), and in Yemen in South-West Arabia (*Ibid.*, ii. p. 171), and an examination of the winds in the *Challenger* maps shows that the prevalent direction is such as to explain this. These conditions have been indicated on the maps by an extension of the 25 mm. (1 inch) line round these districts, but in the absence of exact records this is an indication and not a precise boundary of a rainier region.

In Madagascar the rainfall is found chiefly on the eastern mountain slopes. The south-west is dry, with less than 50 mm. (2 inches) of rain, but the north-west has over four times this amount.

Western Asia, etc.—Armenia, the north of Persia, and the mountains round East Turkistan all receive a fair supply of rain in April—over 50 mm. (2 inches). In the Ferghana valley the rainfall is lower—Khojent, 23 mm. (0·9 inch); Kokan, 24 mm. (0·9 inch); Namangan, 21 mm. (0·8 inch). Except here, we have a higher rainfall—Aulie-Ata, 44 mm. (1·7 inch); Tashkent, 54 mm. (2·1 inches); Gulcha, 77 mm.; Samarkand, 77 mm. (3·0 inches).

At Merv the precipitation is only 29 mm. (1·1 inch), but on the Iranian plateau at Meshed it is 49 mm. (1·9 inch), and at Kabul we find the mean of three years' observations is 56 mm. (2·2 inches). The rise of the Murghab in spring (Hann's 'Klimatologie,' iii. p. 193) speaks of rainfall as well as of melting snows, and we may still regard the mountains here as well watered in April.

Indian Area.—The south-west of India is beginning to receive the rains, which already fall abundantly in Ceylon before the end of April, where south-west winds begin to struggle with the north-east for mastery.

In the delta region, the Khasi hills, and the Assam valley, the rain has increased. The temperature gradients fall to the north-north-east north of the Bay of Bengal, and the air drawn in from over this warm ocean is rapidly cooled. The centre of low pressure lies to the west of the head of the delta, but the winds drawn westwards are warmed as they pass over an ascending temperature gradient. In this month the cyclonic storms attendant on the change of monsoon begin, and are accompanied by rains.

Asia-Australasian Area.—The lowest line of the baric trough still lies south of the equator in the centre of this region, which receives heavy rains between 5° N. and 10° S. The north-east trades still blow on the Philippines and Formosa, and moisten the exposed slopes, while those on the lee side remain dry. But the beginnings of a change are traceable in the winds and rains of Southern China.

At Hongkong, the precipitation has increased from 88 to 138 mm. (3·5 to 5·4 inches), and at Canton from 116 to 216 mm. (4·6 to 8·5 inches). Further north, at the mouth of the Yang-tse Kiang, the rainfall has not yet altered, but higher up the river the rainfall has increased considerably.

	Wuhu.	Kiukiang.	Hankau.	Ichang.	Chunking.
	mm. ins.	mm. ins.	mm. ins.	mm. ins.	mm. ins.
March	82 = 3·2	122 = 4·8	84 = 3·3	51 = 2·0	47 = 1·9
April	117 = 4·6	181 = 7·1	166 = 6·5	122 = 4·8	68 = 2·7

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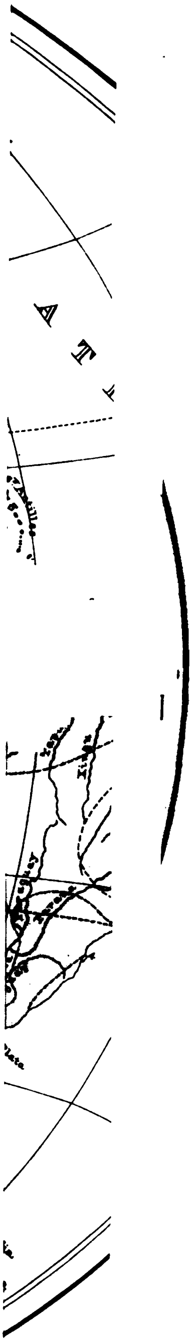
* 'A Naturalist in Mid-Africa,' p. 47. London, 1896.

DIST

1900



In New Guinea the west coast of the eastern peninsula is driest. The north of istralia is now outside the region of heavy rains, except in the extreme north d along the east coast, where it is exposed to the trades.

MAY.

The southern sub-tropical baric ridge now lies between the Tropic of Capricorn d 30° S. It has new heights over South America and South Africa, but that er South-East Australia has lessened, and there is a distinct depression in the ge in the centre of the Pacific. The northern sub-tropical baric ridge can be ced only over the Pacific and the Atlantic. In Europe it divides, surrounding a editerranean low-pressure area. Over Asia a great low-pressure area has developed, d no baric heights exist between those of the southern tropic and that of the arctic n, which in this month stretches right across the pole from Siberia to North nerica.

In the account of the rainfall of the next months, the rainfall in this great Old orld low-pressure area will be described separately.

NORTHERN STORM-WIND SYSTEM.

The differences between the atmospheric conditions over land and water in the rthern half of the northern hemisphere are probably less marked in May than in y other month of the year, except September. North of 40° the gradients both temperature and of pressure are weak, the distribution of rain is more general er the continents, and the isohyetal lines show the contours of the great mounns more clearly.

North American Area.—Only the extreme north of the continent has a tempera-e under the freezing-point. The isotherm of 26°·6 C. (80° Fahr.) reaches as far rth as 39° N. in the west. This is the centre of a small low-pressure area whose is also runs parallel to the west coast, and is much more developed than in April.

Along the west coast opposite this low-pressure trough the winds are mainly sterly. At San Francisco there are ten days with south-west and fifteen days th west winds in May. But in spite of this prevalence of sea-winds, the rainfall ng the Californian coast is very low, in most places less than 25 mm. (1 inch), d at San Francisco itself only 18 mm. (0·7 inch). The isotherms curve southwards shore, and northwards inland, so that the sea-breeze is passing from colder to rmer regions. This is the beginning of the summer conditions, which are inten-ed as the season advances, viz. that of prevalent west winds which bring no rain. is an example of a type of climatic conditions we find all over the world, off le, South-West Africa, West Australia, and North-West Africa, where a great h-pressure area is developed off the coast. These sea-breezes probably are ending winds, and do not blow over a wide extent of ocean; and further, this ribution of pressure with on-shore winds gives rise to upwelling of cold water n below near the coasts, as Sir John Murray has shown so graphically in his dies of the temperature conditions of Scottish lochs.* The air passing over h regions is both relatively cool and dry, and the coasts on which it blows are ong the driest regions in the world during the existence of these conditions.

In May these conditions are found only in an initiatory stage in the Californian ion, where there is enough vapour and a sufficiently slight temperature gradient to permit the high range of the Sierra Nevada, deflecting the winds upwards, to receive a considerable precipitation over the western hill-slopes. But few places receive more than 50 mm. (2 inches) of rain. Farther north the winds blow from many directions, but those from the south are commonest. The coasts are well watered, but have not so great a precipitation as in earlier months of the year.

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* See *Jour. Scottish Met. Soc.*, Ser. 3, Nos. iii., iv., 1886–87; *Scottish Geogr. Mag.* iv. 345–365, 1888, and xiii. pp. 1–20; *Proc. Roy. Soc. Edinburgh*, xviii. pp. 139–288, 1891.

The eastern slopes of the Rockies, which are now reached by the winds moving towards the western depression, are also moistened by rain, and the rainfall is greater than 50 mm. (2 inches) over the western mountains north of 40°, except in the extreme north. Even here the region receiving less than 25 mm. (1 inch) of rain probably does not come south of the arctic circle, although further east it extends as far south as 60° N.

Over Hudson Bay the winds are directed towards the western low-pressure area, and bring rain to the lands lying in the south-west.

The eastern isohyet of 50 mm. (2 inches) extends to the 105th meridian west of Greenwich, and almost meets the western isohyet with the same value.

The east coast rainfall has increased, and that of the Gulf plain has moved northwards and westwards beyond the Mississippi. Between the Mississippi and the south of the Alleghanies we find a slightly more easterly tendency in the average wind direction, and the rainfall is less than 100 mm. (4 inches).

European Area.—The pressure conditions over this region are on the whole indefinite in May. The northern sub-tropical Atlantic high-pressure area has extended its bounds, and the Mediterranean low-pressure area remains, but there are slighter gradients between the two. The Asiatic high-pressure area has disappeared, except in the extreme north of Siberia, and given place to a great low-pressure system. The undecided pressure conditions are observed in the sub-arctic low-pressure area, which has one centre over South Greenland, one over the north-west, and one over the south-east of Scandinavia, one over Finland, and a fifth in the middle Volga. This series of European minor low-pressure areas joins the Icelandic depression to that of Asia, which we shall discuss later.

There is now no great centre of atmospheric action forcing strong winds on the west coasts, whose rainfall is low, and only in isolated mountainous regions exceeds 100 mm. (4 inches). The British Isles are in the high-pressure area, and, while the west coast is still rainier than the east, the difference between them is not very great. The mountains of Europe now stand out as rainy regions compared to the plains around. This is well seen in the case of the Harz, the Vosges or the Schwarzwald, the Cevennes, and the Alps, and when the line for 75 mm. (3 inches) is traced, the Carpathians and North Apennines also stand out in deeper tints, showing heavier rainfall.

The rainfall area of over 50 mm. (2 inches) curves round the seaward sides of the mid-Volga depression. On the east of this depression another area with over 50 mm. (2 inches) of rain is formed over the Urals.

The Mediterranean depression is now well isolated, although with gentle slopes. The winds blow in on all sides from the land, except in the south of France and north of Spain, and in these regions alone is there a heavy rainfall. The Eastern Mediterranean has assumed its dry summer conditions.

SOUTHERN STORM-WIND SYSTEM.

The winter rains of the west coast of South America are beginning to be felt as far north as Valparaiso, and a belt of excessive precipitation, over 200 and even over 300 mm. (8 and 12 inches), has developed. In the southern part of the Plate basin there is no very great change from April.

In South Africa the increasing rainfall in the west, and the diminishing rainfall in the east, are very apparent. The Cape peninsula now receives over 100 mm. (4 inches) of rain, and the south coastal strip 50 mm. (2 inches), but north of this little rain falls.

The south of Australia shows an analogous picture. On the south-west and south coasts the rainfall is greater than in April, and the isohyetal lines tend to run west and east, save in the immediate neighbourhood of the east coast.

STEADY-WIND SYSTEM.

In May the zenithal midday sun lies between 15° 14′ N. and 22° 0′ N.

The sub-equatorial baric trough in May lies north of the equator, which it touches only in the Central Pacific. From this region it curves northwards to 30° N. in the Punjab, where it is united to the southward curving sub-arctic trough, which has its fullest and most complete development in the summer months. In America there is also a northward curving of the low-pressure area.

American Area.—The equatorial rains affect Central America in May as far north as the isthmus of Tehuantepec.

There is also a centre of low-pressure to the west of Central America, and the north-east winds bring much moisture, which is precipitated on the eastern slopes of the mountains. All the region south of the Tropic of Cancer has an abundant rainfall, over 100 mm. (4 inches), except the north-west of the Yucatan peninsula and the west of Mexico, which lie on the lee side.

The isthmus of Panama, the east coast north of it, and the west coast south of it, receive heavy rains, over 200 mm. (8 inches), and in the inmost curves of both coasts more than half as much again—Colon, 290 mm. (11·4 inches); Gamboa, 310 mm. (12·2 inches); Bienaventura, 663 mm. (26·1 inches).

The centre of the low pressure trough passes from the Pacific eastwards, not far from the north coast of South America. On the ocean side much rain falls, and the region round Cayenne has more than 400 mm. (16 inches), while the Guiana highlands, the eastern half of the Amazon basin north of the main stream, and the north-east and east coastal plains of Brazil, as far south as Bahia, have a precipitation of over 200 mm. (8 inches). The observations for one year at Iquitos show a mean precipitation in May of 254 mm. (10 inches). It may be that the 200 mm. line should be extended to the west, so as to include Iquitos. This has not been done on the maps, because there is no cause which would make the mean precipitation relatively so much greater here than at Manaos in May. If we consider the returns from Iquitos and the stations nearest to it for April, May, and June, we find—

	April.	May.	June.
	mm. ins.	mm. ins.	mm. ins.
Iquitos	165 = 6·5	254 = 10·0	189 = 7·4
Manaos	332 = 13·1	186 = 7·3	153 = 6·0
S. Antonio	279 = 11·0	151 = 5·9	65 = 2·6
Bogotá	244 = 9·6	165 = 6·5	81 = 3·2

All show a steady decrease except Iquitos, and, until further observations prove the contrary, it is better to assume that the observations at Iquitos were made in an exceptionally wet May.

African Area.—The hottest region of Africa, enclosed by the isotherm of 32°·2 C. (90° Fahr.), embraces the Northern Sudan and much of the Sahara. The pressure is lowest between Lake Chad and the great bend of the Nile. The isohyets have also moved northwards. West of Cape Three Points, round the

Niger delta, and in Kamerun, there is a very heavy rainfall, and the region receiving more than 200 mm. probably extends over most of the Benué basin, and almost as far east as Lakes Tanganyika and Albert.

There is very little rain south of 5° S., and only on the highlands north and south of Nyasa are there districts with a considerable precipitation. The east coastal plain northwards from 10° S., however, is well watered, and very heavy rains fall in the district round the incurve, of which Mombasa is the centre. Much rain is precipitated from the air drawn over the Abyssinian highlands, and rain falls both north and south of Somaliland.

The rainfall of Madagascar is entirely on the east coast facing the trade-winds, and the west coast and the opposite coasts of the mainland in the lee of the island have a low rainfall.

Malay-Australian Area.—The south-east trades bring a moderate rainfall to the east coast of Australia. The north-east coast of New Guinea has a much heavier rainfall than the rest of the island, while in the case of the Macassar peninsula of Celebes most rain falls in the south-west. The other islands and the Malay peninsula are wetter in the south and west than in the north and east.

The rainfall of the western part of the archipelago is dependent on the Old World low-pressure area, which we must now study.

The Old World Low-Pressure System.

South of a line drawn from Cape Verde to the Lena delta, the pressure over Asia and over Africa, as far as 10° S., is less than 29·9 inches (say 760 mm.), and the triangular area, whose points are the Niger bend, the south of Sumatra, and the sea of Okhotsk, has less than 29·8 inches (say 757 mm.). Along the south side the winds tend to be south-west, along the east side south-east, and along the north side north-west. As there are oceans to the south and east of most of this area the rainfall on the exposed mountain slopes is great, and we find the south-west regions open to the ocean rainy in the south, and the south-east regions similarly exposed wet in the east.

The different conditions of water and land-distribution and of elevation modify or intensify this.

In the case of India we find the deepest depression of this low-pressure area over the Punjab, but the axis of lowest pressure curves southwards along the east coast of the Deccan. The south-west winds have not yet reached Bombay, where the rainfall is 11 mm. (0·4 inch), but the monsoon has broken in the south before the end of the month, and at Calicut the rainfall is 234 mm. (9·23 inches)—*cf.* April—82 mm. (3·21 inches), and at Colombo, where the rains began in April, it is now 314 mm. (12·36 inches)—*cf.* April—286 mm. (11·26 inches).

Air passes up the Ganges valley towards the Punjab depression, and here also in May the rains have begun, but they are still confined to the district between the delta and the mountains due north, to Assam and the hills to the south. The Tenasserim coast also feels the full effects of the south-west winds and has a heavy rainfall—*e.g.* Mergui, May—459 mm. (18·08 inches), April only 153 mm. (6·03 inches).

The equatorial and monsoonal rains are felt over the Malay peninsula and Southern Siam, and the latter pour over Southern China.

JUNE.

In June we find the pressure areas in their northern summer and southern winter forms. The southern sub-tropical high-pressure ridge remains with its lowest region in the Pacific.

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North of this we have now to distinguish between the sub-equatorial trough of
w-pressure and the sub-arctic baric trough rather than the sub-tropical and polar
igh-pressure area. The former are united by other baric troughs passing north and
across the Old and New Worlds. This is homologous with the pressure
ution over the southern hemisphere during the southern summer. In
rth America this summer continental trough has a well-marked hollow.

Old World there is a great depression, greatly intensified since May, lying
t west and east in the south, but curving to the north in the east, forming
arc concave to the north-west, between the Tropic of Cancer and the arctic
ircle. The form, the vast extent and the position of the Old World land-mass
etermine this huge low-pressure area. The steady rise of the baric gradient from
he thermal equator to the pole is what one might expect in a land hemisphere.
he curved minimum line is parallel to the coast, and shows the influence of
oisture on pressure.

In this month the average temperature over the Old and New World continents
nowhere below the freezing-point at sea-level.

NORTHERN STORM-WIND SYSTEM.

The North Pacific and North Atlantic high-pressure systems have both grown in
xtent and height, and the low-pressure areas to the north have diminished, while
hose over the middle latitudes of the continents have increased in importance. The
ucked from the high-pressure area over the oceans into the very heart of the
nts, more than 25 mm. (1 inch) of rain falls in June over all the land between
N. and the arctic circle, except in the south-west of the continents.

No *American Area.*—The temperature over nearly the whole of North
a is over 10° C. (50° Fahr.), over 32°·2 C. (90° Fahr.) between 15° N. and
N. except near the coasts, and over 35° C. (95° Fahr.) in the centre of this

The low-pressure hollow has its axis running north-south, and its greatest
pression about 35° N. West and south of this the rainfall is very scanty, both
ar the coast and among the mountains. At San Francisco the precipitation is
w only 3 mm. (0·1 inch).

In the Upper Sierras at Bowman Dam, which had a rainfall of 64 mm. (2·5 inches)
May, there is only one-third of this 20 mm. (0·8 inch) in June.

The isohyet of 50 mm. (2 inches) runs almost due west-east across the con-
nent near the 60th parallel. East of a line following the meridian from Win-
peg to the Gulf of Mexico, and south of another from Winnipeg to New York
ity, nearly the whole area has a rainfall over 100 mm. (4 inches). The coastal
north of the Gulf of Mexico and most of Florida has half as much again, a
aning of summer monsoonal rains. The prevalent winds in the south-east of
United States, where the rainfall is heaviest, are from south to east, flowing in
ds the low pressure. In New England and Eastern Canada the prevalent
inds blow seawards, and here we find a lower rainfall in this month. Storms,
ny of which passed over this region earlier in the year, are now few and less
and result in much less rain.

uropean Area.—The sub-tropical North Atlantic high-pressure area has
d in area and importance, it no longer surrounds the Mediterranean depression,
part of that existing in May is now continuous with the greater low-
area to the east.

The indefinite pressure conditions to the north and east of it have become more
hrough the expansion of the Icelandic low-pressure area to the west, making
continuous with that of the North Pacific, and the expansion of the great Old

World summer low-pressure area to the north-west absorbing the minor depressions over North-West Russia. Now only the Scandinavian depression lies in the flat ridge between the Icelandic and the great Old World low-pressure areas.

Most of the British Isles lie within the high-pressure area, and the distribution of rainfall does not materially differ from that of May, except that the rainfall is slightly heavier both in the east and in the west.

In France and Spain the rainfall has diminished both on the coasts and inland, but further east the rainfall is distinctly heavier. The area, with more than 50 mm. (2 inches), has extended across most of European Russia, and passes eastwards along the 60th parallel almost to the Lena. Only the extreme north has less than 25 mm. of rain.

In the Mediterranean region the dry conditions are spreading westwards and northwards.

Looking at Europe as a whole, the isohyets are seen to run east and west, and both north and south are in regions with a low rainfall, the band of highest rainfall being in the middle, with the 50th parallel as its approximate central line. The central mountain regions stand out even more markedly than the coastal highlands as regions of heavy rain. The rain is less of the persistent type connected with the winter storms, but now frequently comes in sudden and heavy downpours. The temperature changes, and the resultant air-movements are most active in regions of varied relief, and the mountainous districts receive the rains less from steady currents of moisture from the ocean, than from the uprising of warm air which can hold so much vapour at the high temperatures common at this season at the ground level. At the same time, the moisture of oceanic origin cannot be neglected in considering the sources of rain-water.

SOUTHERN STORM-WIND AREA.

The winter winds and rains are now in full activity in the south. In South America, at Valdivia, the precipitation is 468 mm. (18·4 inches), and at Puerto Montt 307 mm. (12·1 inches). The southern coasts have no great seasonal changes in the rainfall, but on the east coast we find indications this month of a slightly less arid condition. Here the baric gradient is very steep. North of the Plate high pressure prevails, and the gradients are slight, and we find less rain over the region east of the Parana than heretofore.

In South Africa the precipitation has increased in the south-west, but the region receiving more than 25 mm. (1 inch) has almost disappeared in the south-east, where the proportion of winds from between south and east has diminished.

The isohyets have moved both northwards and westwards in South-West Australia. Hardly any of the east coast has now a heavier rainfall than 100 mm. (4 inches). The west of Tasmania and New Zealand are also much wetter than the east.

THE STEADY-WIND SYSTEM.

In this month the sun is in the zenith furthest north. At the beginning of June it is overhead at 22° 8′ N., and at the end of the month at 23° 10′ N., but on the 20th and 21st it is over 23° 27′ N.

The sub-equatorial baric trough is north of the equator, to which the northern edges of the southern sub-tropical high-pressure area almost extend. There are few regions south of the line with a rainfall heavier than 200 mm. (8 inches).

American Area.—One of the southern districts with excessive precipitation is the narrow-coasted strip between Bahia and Cape San Roque, exposed to the south-east trades.

North of the line the Guiana coast, the southern members of the Lesser Antilles, and Central America from Panama to Tehuantepec, have a rainfall which exceeds 200 mm. (8 inches), except in Yucatan, which, with the Greater Antilles and the northern members of the Lesser Antilles, receives less than this amount. In the east of Nicaragua and on the mountain slopes facing the south-west shores of the Gulf of Mexico, as well as on the western mountains of Guatemala, the rainfall is over 400 mm. (16 inches).

The western mountain rainfall is probably a monsoon rain, but the data, both for the extent of the wettest region and for the distribution of winds and pressure, are too scanty to allow exact mapping of this region.

In the north of South America there is a brief break in the zenithal rainfall, the so-called *veranito de San Juan*, which usually takes place at the end of June, and represents the northern extension of the solsticial dry season of equatorial regions.

It is very difficult to estimate the region where this dry St. John's summer reduces the rainfall to less than 100 mm. (4 inches), and the only records giving a smaller amount are those of Bogotá. The region of lower rainfall over the Llanos, and including the Bogotán plateau, must therefore be looked upon as a diagrammatic expression of the occurrence of the dry period, and not as a perfectly definite area.

African Area.—In Africa hardly any rain falls south of the equator, except on the coastal regions north of Zanzibar and in Madagascar. Madagascar presents a great contrast as regards the rainfall in east and west at this season. The south-east trades bring abundant rains to the east coast, while the west is very dry. At Tamatave 310 mm. (12·2 inches) fall, at Antinanarivo only 8 mm. (0·3 inch), and at Mayunga, on the west coast, there is no rain at all.

North of the equator Africa really lies in the western section of the great Old World summer low-pressure area, and in the west there are characteristic heavy monsoon rains, and a heavy precipitation probably occurs over the Southern Central Sudan.

Malay-Australian Area.—South of the equator the rainfall is lower than in May, and the only regions with a heavy precipitation lie within the influence of the Old World low-pressure area.

OLD WORLD LOW-PRESSURE SYSTEM.

This great low-pressure system is now a uniform depression with gradients sloping downwards from the Niger bend, from North-East and from South-East Asia to the region of lowest pressure over Baluchistan. The axis of minimum pressure runs from the Niger bend almost due east to Assam, and thence north-north-eastwards almost to the New Siberian islands. South and east of this line the rainfall is relatively great compared with that north and west of it. In some regions it is very heavy, and only in the region between the north-east of Africa and the Indus is the rainfall really low. This region has a coast-line with an approximate south-west north-east trend, the same as that of the prevalent winds. Many other relatively dry regions lie on the lee side of the mountains which face the rain-bearing winds.

These exposed and rainy regions generally lie on the west or south-west side of the land masses in the south, and on their south or south-east side in the east.

We find in India, which is now completely under the influence of the S.W. monsoon, the western slopes of the Western Ghats with an excessively heavy precipitation, over 800 mm. (32 inches) in many regions, while the rainfall on the Coromandel coast is not a sixteenth of that amount. The Indian rainfall map illustrates also how, in the lee of a great range of mountains, there is often a district with a lower rainfall than the land still further to leeward, but less in the immediate neighbourhood and protection of the mountains. In India such a district with less than 50 mm. (2 inches) of rain lies between Mysore and Bellary.

A similar region with relatively low rainfall lies north-east of the Khasi and Jaintia mountains, whose southern slopes receive heavy rains, those at Cherrapunji being notoriously great, and in June reach the enormous average of 2744 mm. (108 inches), which is only surpassed in July, when the mean is 2910 mm. (115 inches), enough rain in two months to cover the ground to a depth of more than 5½ mètres, or 18½ feet!

The interior of Burma is another region with relatively low rainfall, and so are the Menam valley and the east coast of Assam, all lying to the east of high mountains. Kienchau, in Hainan, has a June precipitation of 127 mm. (5 inches), which represents that of the sheltered rather than the windward side of the island, which probably receives heavy rains like the east coasts of Tongking and of China. In the lee of Formosa there is a region of lower rainfall along the China coast, but it is probable that the rainfall in the mountainous regions farther inland is not diminished, and only the coastal region has been coloured to show the effects of this Formosan screen.

In Japan, in Korea, in the Shantung and Liao peninsulas, we find the same relationship of wetter windward and drier leeward regions. On a smaller scale it is traceable round Vladivostock, and on a larger scale in the lee of Kamchatka and probably of Sakhalin. The observations on the coast opposite this island, and those on the island itself, all show a precipitation of less than 50 mm. (2 inches); but all the insular stations are on the west side of the mountains, whose eastern slopes are almost certain to have a more abundant rainfall. In June the shores of the Sea of Okhotsk, not lying in the lee of Sakhalin nor of Kamchatka, have a precipitation over 50 mm. and even over 100 mm. (2 and 4 inches).

JULY.

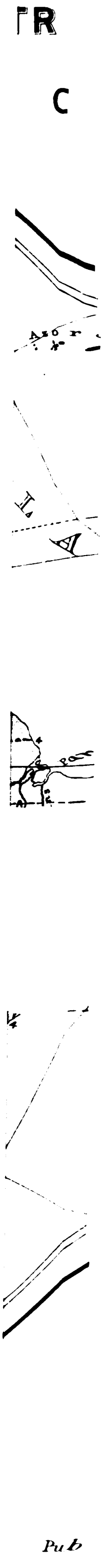
The temperature is a maximum and the pressure a minimum over northern, and just the reverse over southern lands.

The heat equator lies north of the Tropic of Cancer over the land, and between that tropic and the equator over the sea, except in New Guinea, which lies south of the line, and has no land to the north of it.

This month marks the widest extension and the greatest depth of the Old World low-pressure area. It is now continuous with the North Atlantic and the North Pacific low-pressure areas. The gradients are gentle to the slightly higher pressure area round the north pole, but steep to the high southern sub-tropical ridge. This baric ridge has its maximum development in this, the typical winter month of the southern hemisphere, and runs along the 30th parallel, except in the Pacific, where it curves 10° further north. The Atlantic and the Pacific northern sub-tropical high-pressure areas are likewise very extensive, so that, outside the Old World low-pressure area, the sub-equatorial baric trough is a minimum both in breadth and depth.

NORTHERN STORM-WIND SYSTEM.

The relationship of temperature and pressure conditions over the land and water surface in this northern storm-wind system differs radically in July from those of January. The isotherms bulge northwards over the continents. They reach their maximum northern points in the north-west of North America and the north-east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of Asia, and curve sharply southwards along the shores of the Pacific. This sudden trend southwards also takes place along the shores of the Atlantic, but to a less marked degree. The isotherms reach farthest south off the west coast of North America, and in the Atlantic they pass into lowest latitudes off the east coast of North America. The isotherms thus slope towards the north and west across the e, to the north and east across the Atlantic, where, off the north-west of urope, they reach a secondary northern maximum. Over the northern continents e perature is not lower than 10° C. (50° Fahr.), except in the extreme north- and over a very large area of North Africa and South Asia, the thermometer an average reading of over 35° C. (95° Fahr.).

There are two well-marked high-pressure areas over the two oceans, with centres nearer the eastern than western shores; and two low-pressure areas come between, of which that over Asia is very large and deep, and that over North America is small and shallow.

The North Pacific low-pressure area is represented by an arm of the Asiatic low-pressure area which stretches over the Aleutian islands, and the Icelandic low-pressure area of January is represented only by two very shallow depressions west and east of Greenland.

There are two minor depressions in West Europe over the Iberian and Scandinavian peninsulas.

The rainfall is typically continental. The higher temperature of the air permits a greater mass of water existing in the atmosphere as vapour, and as the winds pass inland from the oceans they carry this moisture with them. As they proceed they reach warmer instead of colder regions, and their moisture capacity increases instead of diminishes. The cooling of the air is brought about by its gradual ascent, due to the increasing height of the land, and even more to the upwelling of the air over the interior. The whole area is infinitely better watered, hardly any regions receive han 25 mm. (1 inch) of rain in July. The exceptions are the extreme northern ons round the north polar high-pressure area, where the winds blow from regions temperature is very little over the freezing point to warmer lands, and the untain-bounded inland basins of the Central Asiatic and the North American rdi areas.

evaporation of surface water and the transpiration of plants are also sources of e in the summer months. The locally unstable condition of the atmosphere, cially in rugged regions, has already been noticed as an important factor in about the rainfall in months when the storm winds are less frequent and violence. The low pressures of the interior of the continents, however, ensure a steady inflowing of winds from the high-pressure areas over the oceans, although these are rarely of great intensity.

The rainfall of July is a maximum over much of the northern hemisphere, except in the sub-equatorial regions with two rainy seasons in the year, and in the coastal regions with winter storm rains. Considering the whole land surface of the northern hemisphere, it is probable that a greater volume of water is precipitated over it in July than in any other month; but this cannot be definitely proved until urements are made, which I hope to be able to undertake at an early ate, from the maps which accompany this paper—the first available for the se.

North American Area.—The small depression which lies over this continent has ts major axis along the 250th meridian, and its minor one along the 40th parallel. To the east of this meridian most of the land receives over 50 mm. (2 inches) of in July, and much of the south-eastern quadrant, which has the intersection this meridian and parallel as apex, has a rainfall of over 100 mm. (4 inches), but this latter region is of somewhat smaller area than in June. The Gulf coast still receives heavy rains.

With regard to the Arizona-New Mexico region, Prof. Henry, in the most recent tables published in 1897 (for an advanced copy of which I am indebted to Prof. Willis L. Moore, Chief of the United States Weather Bureau), shows an average rainfall of over 50 mm. (2 inches) at all stations except Yuma and Phœnix; and in the north of Mexico, at Chihuahua, the mean for three years is 153 mm. (6·0 inches). Prof. Henry points out that the summer rains "are remarkably persistent, and very rarely weaken during either July or August. Occasionally the rains may fail for one of the two months, even at higher level stations, but it seldom happens that there is a total failure in both months. At lower levels—100 to 2000 feet—failures are much more frequent." He explains the rains as due largely to convectional action, but believes that it is not the sole cause.* This we may find in the inflowing of air from both east and west to the low-pressure areas lying to the north.

In the west the dry area is found as far north as Vancouver island, and stretches beyond the eastern slopes of the mountains. The inflowing winds, however, bring rain to the south-west shore region of Hudson Bay.

The high-pressure area has now finally disappeared from the north of the continent and a minor depression has developed to the north of Labrador. The rainfall over the lands round Davis strait is greater than in June.

European Area.—The temperature over all Europe has distinctly increased, and the pressure diminished. The anti-cyclonic conditions do not extend so far north nor east, and the independent Icelandic low-pressure area has once again appeared to the south of Iceland. Minor depressions are found over Scandinavia and Spain.

The rainfall is greater than in June all over Europe. As far south as Brittany there are evidences of a return of the west coastal rainfall, which was relatively low during the persistence of the high-pressure. But although we observe more traces of coastal rainfall in July than in June, we also find a greater development of continental rainfall. Excluding the Mediterranean region, the precipitation has increased in the east as well as in the west of Europe, and none of this region, except the extreme north, has less than 50 mm. (2 inches) of rain.

Over the British Isles only a very small area near the Thames estuary receives less than 50 mm. (2 inches) of rain. The most notable change, however, is in Sweden, where the 50 mm. (2 inches) isohyetal line does not appear in July, as the rainfall is higher than 50 mm. at all stations. The low-pressure area lying along the east of the Scandinavian mountains draws the air upwards from the Baltic.

The Mediterranean region is very dry in July, as it lies within the north-east trade-wind area. Even a low-pressure area, which, however, is not of great size, developed over the Iberian peninsula, does not suffice to suck in moist air to water the land, and the increase of temperature gradients from the coast inland also works in favour of drought.

SOUTHERN STORM-WIND SYSTEM.

The intensifying of the southern sub-tropical high-pressure area has had the effect of slightly diminishing the South American rainfall beyond 30° S., except between 30° and 40° on the west coast. La Serena has its maximum precipitation of 13 mm. (0·5 inch) this month, and Santiago and Valdivia, the two other places with a long series of observations, attain their maximum also of 81 mm. and 580 mm. (3·2 and 22·8 inches) respectively. East of the Andes, both on the inland and coastal plains and in the extreme south, the precipitation is distinctly lower than in June.

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* Alfred J. Henry. 'Rainfall of the United States,' p. 35. Weather Bureau, Bulletin D. Washington, 1897.

Both in the east and west of South Africa the rainfall is lower in July.

In Australia the west coast rainfall has not altered much, but the east is very dry, and only a narrow and short strip of coast north of 30° S. receives more than 50 mm. (2 inches).

In Tasmania the rainfall has increased at all stations, and at most reaches its maximum in July.

In New Zealand the west coast rainfall has not altered greatly, except that it is higher round Cook strait. The east is slightly drier than in June.

STEADY-WIND SYSTEM.

The sun is in the zenith at noon at 23° 5′ N. in the beginning, and at 18° 10′ at the end of July. The sub-equatorial baric trough is a minimum and the Old World low-pressure area a maximum.

American Area.—In Central America there is no very great change from the June conditions. The rainfall has very slightly increased in Mexico, especially in the west; but south of the isthmus of Tehuantepec it has decreased in the west, except at San Salvador, and increased in the east, where it reaches its maximum for the year at Puerto Barrios (504 mm., or 19·8 inches), Bluefields (468 mm., or 18·4 inches), Greytown (974 mm., or 38·3 inches), and Limon (752 mm., or 29·6 inches).

In South America the brief St. John's summer has ended in the north, but in the Western Cordilleras we find the equatorial rainfall type, with a double wet and dry period, prevailing as far north as 7°–8° N., and in the Upper Medellin and Cauca valleys smaller precipitation in July, but in the Antioquia mountains this dry season is distinguishable only in the low valleys.*

The north-east coastal plain still receives heavy rains, but it is approximately only two-thirds that of June. The coastal region south of Cape San Roque has the same precipitation in June and July in the north, but the amount is greater in July near Cape Frio.

African Area.—The highest isotherms lie farther north in July than in June, and the low-pressure area is narrower in the west. The rainfall, however, is heavier along the coast from Sierra Leone northwards, but in Upper Guinea it is slightly lower than in June. The rainfall distribution, however, has not altered in general character, but we may assume a northward migration of the isohyets.

The northern boundaries of the different rainy regions are merely rough lines, whose exact position cannot be determined, owing to the complete absence of exact data, for practically the whole of the Sudan from west to east. Deflections of the 25 mm. (1 inch) line have been shown at Air and Tibesti, for as Prof. Hann says ('Klimatologie,' vol. ii. p. 146), "In den Gebirgen von Tibesti sind die Regen reichlicher, ebenso auch in Air; Gebirgslandschaften ziehen die tropischen Regen viel weiter nach Norden bis zum und über den 20 Breitegrad." The positions of the lines have been fixed as far as possible from the description of the rainfall conditions given by Dr. Hann, and they give a rough diagrammatic representation of the broader facts.

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* A. Hettner. 'Regenverteilung, Pflanzendecke und Besiedelung der tropischen Anden.' *Richthofen Festschrift*, Berlin, 1893. *Cf.* also 'Die Kordillere von Bogotá,' II. Das Klima, *P.M. Erg. Heft*, 104. Gotha, 1892.

For Abyssinia there are a few rainfall means, but all for too short periods to be satisfactory, which guide the trend of the isohyets in the east. Both in the north and south the Somali peninsula is dry in July (Hann, 'Klimatologie,' vol. ii. p. 128, 129), and short period returns exist for a few stations in East Africa, and have determined the southern limits of the different areas. It is an open question whether the region coloured over 200 mm. in the map should be continuous, or consist of two regions with a drier intermediate one in the heart of the continent. The region south-west of Lado, which has a rainfall of 105 mm. (4·1 inches), may perhaps be even wetter than shown, for here lies the gloomy forest through which Stanley forced his way with so much trouble.

Malay-Australian Area.—As in June, this region lies on the south-east outskirts of the great Old World summer low-pressure area.

Tropical Australia is almost rainless, even in the extreme north, and the northern parts of the smaller Sunda islands are also very dry. Southern New Guinea is relatively dry, and only the eastern shores receive much rain. The minimum monthly rainfall is recorded at most stations in Southern Sumatra and Borneo in July. Western Sumatra and Central Borneo, and most of the Philippines have heavy rains in July.

THE OLD WORLD GREAT LOW-PRESSURE AREA.

The area with a pressure under 754·3 mm. (29·7 inches) has widened from north-west to south-east, but somewhat contracted in the south-west and the north-east, so that it is less elongated. The lowest pressures recorded in any month in the northern hemisphere are found between the Southern Punjab and Oman, an area wherein the mean height of the barometer is under 747 mm. (29·4 inches), when reduced to sea-level.

The effect of this deep baric hollow is seen most graphically over the Ganges valley and the North-Eastern Deccan, where the area with over 400 mm. (16 inches) of rain is a maximum in July. Except in the extreme southern tip of the peninsula and in Ceylon, where the summer dry season of the equatorial area prevails, and in regions where the rain is not brought by the south-west monsoon, the maximum rainfall throughout India occurs in July.

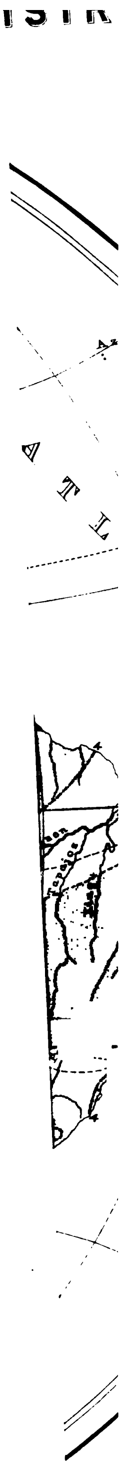
At Cherrapunji the extraordinary amount of 2910 mm. (114·6 inches) falls; at Mahabaleshvar, south of Poona in the Western Ghats, 2718 mm. (107·0 inches); at Màtheran in Bombay, 2228 mm. (87·7 inches); at Lonavala in Bombay, 1819 mm. (71·6 inches); and at Sandoway in Burma, 1575 mm. (62 inches). These stations are among the rainiest in the world; and of others, in other parts of the world, with a rainfall of over 1500 mm. (60 inches) in a month, we find recorded only Debunja, in Kamerun, 1725 mm. (67·9 inches) in September, but this is only a two years' average.

In the Far East the maximum rainfall also occurs in July in parts of Amuria, Korea, and in China north of Shantung, whereas south of this peninsula June was rainier.

In the extreme north the rainfall is distinctly higher at nearly every station. The band of rainfall over 50 mm. (2 inches) now crosses from the Atlantic to the Pacific, and in Asia lies roughly between 50° N. and the arctic circle.

AUGUST.

August differs very little from July in its essential characteristics. The ocean temperatures are maxima in the northern and minima in the southern hemisphere. The temperature over the land has slightly decreased in the north and slightly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increased in the south. The pressure gradients and rainfall on the whole are a little less than in July.

NORTHERN STORM-WIND SYSTEM.

The conditions for convectional rains are not quite so favourable as in July, as the temperature has fallen a little, but those for coastal rains have slightly improved. As the air temperature over the oceans is a maximum, the water held as vapour in the atmosphere over it can also be a maximum. The temperature gradient from ocean to continent is not quite so steep along a parallel of latitude, as in July, and is not very great around the Atlantic, though still steep in the Pacific area. Hence the air passing inland is not so quickly heated as in July. The greater quantity of water in it causes a slight increase in the rainfall at most coastal stations in August, whereas in the interior of the continents there is a slight decrease compared with July.

American Area.—The three high-pressure areas round the north pole and over the two oceans have all slightly extended their bounds, so that the American low-pressure area has been pushed further west, and so modified that it now forms a narrow baric trough running with almost parallel walls from 15° to 55° N. The Pacific gradients are steeper, but the outflowing anti-cyclonic winds bring little rain to the coast, as we have already seen.

The following table shows the changes of temperature and rainfall returns for July and August in the Arizona-New Mexico region. The temperatures are taken from the *Challenger* Report, and the rainfalls from Weather Bureau, Bulletin D:—

Stations.	Temperature (degrees).			Rainfall.		
	July.	August.	A. – J.	July.	August.	A. – J.
Arizona—	C.° F.°	C.° F.°	C.° F.°	mm. ins.	mm. ins.	mm. ins.
Yuma ...	33·3 = 92·0	32·9 = 91·3	–0·4 = –0·7	3 = 0·1	8 = 0·3	5 = +0·2
Prescott ...	22·7 = 72·8	21·7 = 71·1	–1·0 = –1·7	71 = 2·8	76 = 3·0	5 = +0·2
Tucson ...	30·1 = 86·2	28·7 = 83·7	–1·4 = –2·5	61 = 2·4	66 = 2·6	5 = +0·2
New Mexico—						
Santa Fe ...	20·4 = 68·8	19·3 = 66·8	–1·1 = –2·0	69 = 2·7	69 = 2·7	0 = +0·0
Texas—						
El Paso ...	27·7 = 81·8	25·9 = 78·6	–1·8 = –3·2	41 = 1·6	48 = 1·9	7 = +0·3

The decrease in temperature common at all the higher stations probably diminishes the importance of the convectional factor in bringing about precipitation, and the slight gain in rainfall found at nearly every station in the two States, therefore, may be explained by the augmentation of the water vapour in the air and the decrease of the ascending temperature gradient from the Gulf inland. El Paso is only 1°·1 C. (2·0° Fahr.) cooler than Galveston in July, but it is 2°·7 C. (4°·8 Fahr.) in August.

Between British Columbia and the Great Lakes the pressure has risen, and the nfall, except on the outer coastal region, is slightly less.

Further north, over Alaska, there is a district with pressures lower than round the coast, especially to north-west and south-west; and at Point Barrow (July, 30 mm., or 1·2 inch; August, 41 mm., or 1·6 inch), St. Michael's (July, 46 mm., or 1·8 inch; August, 66 mm., or 2·6 inches), Fort Alexander (July, 104 mm., or 4·1 inches; August, 112 mm., or 4·4 inches) is a distinct increase in rainfall, due to the inflowing of the relatively warm and moist air.

In the east of North America, with the westward movement of the high-pressure area, there is a decrease of heavy rains, and the region with more than 100 mm. (4 inches) has considerably shrunk.

European Area.—The temperature, pressure, and rainfall conditions have not greatly changed over Europe. The isotherms and isobars have a slightly more southerly position, which is most marked over Scandinavia and North Russia. The area with a precipitation over 50 mm. (2 inches) is not so great, and the bounding isohyetal lines approach each other towards the Urals instead of running almost parallel. The west coastal rainfall, on the other hand, has slightly increased except in the extreme north, where isobars are weaker.

The following table shows the relationship of the rainfall at coastal and continental stations in July and August for stations with the longest series of observations:—

COASTAL.

	Bodö (23 years).	Kristiansund (25 years).	Bergen (25 years).
	mm. ins.	mm. ins.	mm. ins.
July ...	68 = 2·7	77 = 3·0	150 = 5·9
August ...	67 = 2·6	85 = 3·3	174 = 6·8
A. – J. ...	−1 = −0·1	+8 = 0·3	+24 = 0·9

CONTINENTAL.

	Bogoslovsk (53 years).	Ekaterinburg (56 years).	Slatoust (55 years).
	mm. ins.	mm. ins.	mm. ins.
July ...	73 = 2·9	73 = 2·9	88 = 3·5
August ...	70 = 2·8	62 = 2·4	75 = 3·0
A. – J. ...	−3 = −0·1	−11 = −0·5	−13 = −0·5

The Mediterranean region is still exceedingly dry in August.

SOUTHERN STORM-WIND SYSTEM.

In South America the wettest centre of the winter rain region has moved a little south, but there is no material change from the July conditions.

The rainy area has extended a little in South Africa, and in the south-east traces of trade-rains begin to appear. In the west, as Dr. Buchan has shown, this is the last month with heavy rains over the Cape peninsula, and nearly two-thirds of the total annual precipitation falls in the third of the year between May and August.*

In Australia there are evidences of contraction of the rainfall areas in the south-west and in Tasmania; while the storm-winds do not bring quite so much rain to the extreme south-east or to the east of New Zealand. Here also there is only a very slight modification of the July conditions.

STEADY-WIND SYSTEM.

The sub-equatorial baric trough has widened out, especially over the Atlantic, while the Old World low-pressure area has shrunk. The isotherm of 27° C. (80° Fahr.) has moved southwards over the land south of the equator.

The sub-equatorial rain-belt has also moved southwards with the sun, which is in the zenith at noon at 17° 55′ N. in the beginning of the month, and as far south as 8° 29′ N. at the end of it.

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* A. Buchan. 'Rainfall of South Africa,' 1885–1894. Cape Town, 1897.

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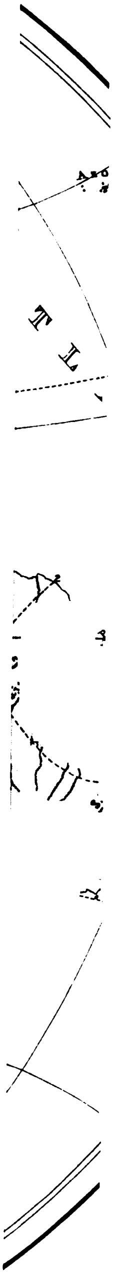

American Area.—Over nearly all this area the rainfall has increased in quantity in the south and diminished in the north. On the north-east coast we have evidence of the beginnings of the second equinoxial dry season, which is by far the more important.

African Area.—The pressure gradients from the Gulf of Guinea towards the north-east do not fall so steeply in August as in July, and the records at Bismarckburg and Baliburg stations away from the coast in this region show a distinct lowering of the rainfall, but in the south at Yaunde there is a slight rise.

	Bismarckburg (6 years).		Baliburg (2 years).		Yaunde (5 years).	
	mm.	ins.	mm.	ins.	mm.	ins.
July ...	167 =	6·6	263 =	10·4	49 =	1·9
August ...	115 =	4·5	203 =	8·0	63 =	2·5
A. – J. ...	–52 =	–2·1	–60 =	–2·4	+14 =	+0·6

The area with a rainfall over 200 mm. has not been drawn over the Southern Sudan and joined to the Abyssinian one with more than this precipitation, owing to this decrease at the northern stations, and as the increase in the rainfall of the southern station does not appear high enough to warrant it.

In the Abyssinian highlands, however, the rainfall is distinctly heavier in August. Somaliland remains dry.

South of the equator the isohyets push much further south.

In the south-east the scanty showers of rain are even scantier, and the east coast rainfall of Madagascar is also less.

Malay-Australian Area.—In Sumatra and Borneo the rainfall has increased with the southern movement of the sun, but in Java and some of the smaller Sunda islands August is the month of minimum precipitation, and this is also the case in Kaiser Wilhelmland, except at Finschhafen.

Relatively little rain falls in British New Guinea, and the precipitation is less than 25 mm. (1 inch) in Northern Australia.

THE OLD WORLD GREAT LOW-PRESSURE SYSTEM.

The area where the pressure is less than 754 mm. (29·7 inches) no longer extends north of 40° N., and has greatly contracted in the south and east, and the gradients in the south are not so steep.

In India the rainfall has diminished in the north and increased in the south-east, and in the north of Ceylon where July was a minimum, but in the south of that island the second monthly minimum is recorded in August.

In the interior of Burma the rainfall has increased in August, and at many stations reaches its maximum, but along the coasts the heaviest rains take place in July.

August is the month of maximum rainfall round the Gulf of Tongking, but farther north the rainfall begins to diminish in this month.

In Southern Japan, more especially round the midland sea, the summer minimum occurs in August, but at most stations in the north August is slightly wetter than July.

SEPTEMBER.

In September the Old World great low-pressure area has almost disappeared, and the sub-tropical baric ridge can once more be traced round the northern hemisphere with three depressions—one over America, one in Siberia over the basin of the Obi, and one in the North-West Pacific. Its crest, however, lies far north of the tropic, and even north of 40° N., except over the Atlantic, and it actually reaches nearly to 60° N. over North-East Siberia.

The southern sub-tropical baric ridge lies farther to the south, and is becoming less well marked over the continents.

NORTHERN STORM-WIND SYSTEM.

Traces of the winter characteristics are beginning to show themselves. The isotherms slope, on the whole, towards the south of east when traced across the continents from west to east. The isotherm of 0° C. (32° Fahr.) just touches the northern coasts of the Old World. The North Atlantic low-pressure area is now well developed in extent, but is still shallow, and that over the North Pacific has once more appeared. The storm-winds strike the western shores where coastal rains are increasing. Storm-winds also help to moisten the east coast. The interiors of the continents are much drier than in July or August.

When the September rain-map is compared with those for April and May, it is at once clear that September has more of the summer characteristics than April, and resembles May in many respects, but that September is the wetter month of the two.

North American Area.—There are six pressure systems directing the winds over North America in September, three high and three low.

The polar high-pressure area extends to the arctic circle, and is flanked by the North Pacific and North Atlantic low-pressure areas, south of which lie the North Pacific and North Atlantic high-pressure areas, which slope down to the sub-equatorial baric trough. The depression, which formerly lay north-south along North America, is much shallower, and has been encroached on in the north-west by the North Pacific high-pressure area, and in the south-east by the North Atlantic high-pressure area, so that its axis is deflected to a more north-east south-west direction. It has lost much of its influence, especially on the Arizona-New Mexico regions, where the rainfall is only 30–60 per cent. that of July, much of which reduction, however, can be explained by a diminution of temperature.

The influence of the re-constitution of the North Pacific depression is traceable in the coastal rainfall north of 40° N., where at most stations it has doubled and at some even trebled in amount compared with August.

East of the Cordilleras the land has a lower rainfall, not only in the heart of the continent, but even near the east coast. The pressure inland and along the coasts is rising, the pressure over the Central Atlantic is diminishing.

The rainfall in the high-pressure area is low, but on the borders where the low-pressure influences are felt, both in north and south, the precipitation is relatively heavier.

Eurasian Area.—The pressure has everywhere increased, and a band of low-pressure, with its axis north-west south-east, is all that remains north of 40° N. of the great summer low-pressure area.

In the west the parallel of 50° roughly separates the northern low-pressure area from the southern high-pressure area. The development of the Icelandic low-pressure area has increased the coastal rainfall in this northern region, and the 200 mm. (8 inch) line appears once more in South-West Scandinavia. With the disappearance of the special high-temperature low-pressure conditions round the

Baltic the rainfall diminishes, and this again forms the characteristic drier region on the lee side of the mountains.

The 50 mm. (2 inch) isohyet no longer runs across Siberia, but finds its eastern boundary near the Urals.

South of 50° we find the 50 mm. (2 inch) isohyet does not reach beyond 25° E., and excludes considerable portions of the North German plain.

In comparing the August and September conditions it is necessary to divide this western area into two regions, a Central European region and a Mediterranean region. In the former the rainfall is less in September than in August; and this is of great economic importance, as it permits the vine to ripen and be harvested further north than where the other climatic conditions are suitable but the moisture is too great in autumn. The Mediterranean region, on the other hand, ceases to be dry, and not merely the isohyet of 10 mm. (or of 0·4 inch) disappears altogether, but even that of 25 mm. (1 inch) ceases to exist save in Andalusia and Southern Estremadura.

In the Iberian peninsula, and in France south of the Loire, the coastal rains have increased, whereas in the Central European region they have diminished; but the Cevennes, the Southern Alps, the Apennines, and the Dinaric-Albanian mountains stand out with a September rainfall double that of August at many stations. The extreme east of the Mediterranean has not yet felt the effects of the return of the northern storm-winds to more southern lands.

With the development of a high-pressure area between the Yenessei and the east coast the rains have greatly diminished at most eastern stations. *Cf.* Yakutsk, August, 59 mm. (2·3 inches); September, 30 mm. (1·2 inch); Irkutsk, August, 62 mm. (2·4 inches); September, 41 mm. (1·6 inch); and on the coast, Nikolaevsk, August, 74 mm. (2·9 inches); September, 70 mm. (2·8 inches); Vladivostock, August, 88 mm. (3·5 inches); September, 60 mm. (2·4 inches). The high-pressure reaches as far south as the north of the Yellow sea, and at Peking the September precipitation is only 40 per cent. of that of August, and at Chemulpho, 54 per cent.

On the other hand, on the south and east of the Sea of Japan the rainfall is much heavier than in August, and in the extreme south reaches its maximum (Miyasaki, 478 mm., or 18·8 inches; Kochi, 456 mm., or 18·0 inches).

Japan has heavy equinoxial rains, with a slight summer and a marked winter minimum between; but on the west coast there is a third maximum in winter, only the spring maximum is very slight in April, and is preceded and succeeded by the two deepest minima in March and May. Taking the Japanese islands as a whole, September is the month in which the greatest volume of water is precipitated on them.

The Southern Storm-Wind System.

The heavy winter rains cease to pour on the South Chilian Andes, where the 100 mm. (4 inch) line is now the highest isohyet. The rainfall has risen over the La Plata region.

In South Africa the western rains have become less and the eastern ones heavier.

In Australia this is also the case.

In New Zealand the precipitation has decreased in the North island with the southing of the sun and the heat and wind-bands, but at some places in the South island the September rainfall is the maximum.

Steady-Wind System.

September is characterized by the breaking up of the great Old World low-pressure area and reappearance of the sub-equatorial baric trough, with only minor communications with low-pressure areas in the temperate belts.

The sun is now zenithal at noon between 8° 7′ N. and 3° S.

American Area.—In Mexico the rainfall has diminished except in the extreme south-east, where it is a maximum at most stations on the slopes facing the Gulf of Mexico, across which the predominating winds blow.

On the Guatemala mountains the rainfall is also very abundant in September, and indeed is a maximum at most west-coast stations from the isthmus of Tehuantepec southwards. Looking at the pressure-maps we find that the axis of lowest pressure passes from the Pacific to the Atlantic across the south of Central America, and the north-east trades rule the Gulf region. The great west-coastal rain is that of the second wet season, due to zenithal position of the sun, which, however, passes over Guatemala early in August. The progress of this west-coast maximum, however, is steadily southwards.

In the western half of South America the precipitation has increased, but in the east it has diminished in September. There is only one season of low rainfall in the Amazon basin. The minimum is in July south of the river, and in August and September on the main stream. At Para, and along most of the east coast from Cayenne to Cape San Roque, there is one dry season, whose minimum occurs in September. At Cayenne there is the trace of a second minimum in February, which is more marked further west; so that this is the northern point of the sub-equatorial coastal region with a single minimum in autumn. The southern limit does not go as far as São Bento das Lagos, where there is a marked double minimum, but it lies south of Pernambuco, where October and November are both very dry. In the interior of North-East Brazil hardly any rain falls between June and September, but there are traces of a subsidiary minimum in February.

In the lower Amazon the 25 mm. (1 inch) line has been drawn to include much of land to north of the stream towards Cayenne (28 mm., or 1·1 inch), although Para has 54 mm. (2·1 inches), because Mr. A. R. Wallace points out that Para is an exceptional place, from a climatic point of view, and also that the dry season lasts three months on the Guiana side of the Amazon near its mouth, and hardly a drop of rain falls during this period.*

African Area.—The heaviest rainfall is in Sierra Leone and in the Kamerun region. The autumn maximum precipitation occurs at several Kamerun stations in September.

The rainfall is less than in August in Abyssinia, but it increases round the Victoria Nyanza and in the lower Congo, as well as in the Angola highlands.

Asia-Australian Area.—Although the temperature is still relatively high, and the pressure relatively low in North-West India and Baluchistan, the gradients to the south are much less steep, and the summer monsoon conditions have greatly weakened. With the exception of the Indus region, the whole of India still receives abundant rains, although the excessive precipitations of the summer months are no longer recorded at the hill stations.

In East Asia the rainfall is less than in August, except in the east coasts of Japan, Formosa, and Anam. The axis of low-pressure now runs south-east from Bengal, and the prevalent winds are between north and east.

The mean precipitations of stations on the Yangtse-kiang show a fairly uniform distribution of rain, slightly increasing in the south and west. On the other hand, in Yunnan, the number of rainy days at Mengtz is ten in September and twenty in August. It is greatly to be desired that a rain-gauge should be sent to this station. Further east there is a great contrast between the rainfall of Hongkong (318 mm., or 12·5 inches) and Macao (269 mm., or 10·6 inches) on the coast, and a station so

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* 'A Narrative of Travels on the Amazon and Rio Negro.' London. 1853 and 1889.

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near as Canton (97 mm., or 3·8 inches), but lying inland. A district of drier land has been shown to indicate this lower rainfall on the lee side of the mountains in the Sikiang valley, but it is quite possible that the 100 mm. (4 inch) isohyet should bend southwards and include all the region between this and the Yangtse river, and that further observations at Chunking, on this river, will show the present mean of 106 mm. (4·2 inches) to be too high, or that the dry district should be of smaller area.

A low-pressure area has formed over the Philippines, and at most stations the rainfall is very abundant. It appears that the winds coming over the South China sea bring most rain, for the heaviest precipitation is recorded at Punta Restinga, 749 mm., or 29·5 inches (four years); Cape Bolinao, 420 mm., or 16·5 inches (five years); at Punta Santiago, 384 mm., or 15·1 inches (five years); and at Manila itself 381 mm., or 15·0 inches (thirty-two years).

The south-east trades still blow across the Archipelago north of Australia, and only the eastern coasts have a large rainfall, while those of most of the small Sunda islands and the north of Australia is under 25 mm. (1 inch).

OCTOBER.

The climatic peculiarities of the northern winter and southern summer show themselves in October more than those of the opposite seasons. The northern sub-equatorial baric ridge is fully developed, except over the Pacific, between 150°–190° of longitude, and its crest follows the 40° parallel, curving southwards over the oceans and northwards over the land. The southern sub-tropical high-pressure ridge is still continuous, but is lower and constricted over the continents. It is highest near 30° S.

NORTHERN STORM-WIND SYSTEM.

The polar high-pressure area, and the North Pacific and North Atlantic low-pressure areas, are all well developed, the latter exceptionally so. The high-pressure area has spread over the continents, and with the development of outflowing winds comes a diminution in the rainfall. Both continents are now crossed from north to south by a dry area with less than 25 mm. (1 inch) of rainfall.

North American Area.—The pressure has risen over North America until now the arctic and the Pacific and the Atlantic sub-tropical high-pressure areas are all united across it. The intensity of the Pacific high-pressure system has diminished, while a baric height has grown up south of the Great Lakes between the Mississippi and the east coast. Along the axis of high-pressure is one of low rainfall. The Pacific high-pressure area still affects the west coast south of San Francisco. The now better developed low-pressure area to the north of it sends out winds which carry water to the coasts of Washington, British Columbia, and Alaska, where the precipitation is greater than in September. North and east of the coastal mountains rain still is found, but not so plentifully as in the previous month.

The high-pressure area south of the Great Lakes has modified the conditions there, so that less rain falls than in September, and it affects all the south-east of the United States. The coastal strip of 100 mm. (4 inches) rainfall is greatly reduced in October, except north of the Hudson. No Gulf rainy region penetrates the Mississippi valley, and in this respect the rain distribution is quite unlike the winter as well as the summer type. The summer monsoonal conditions are over, but the winter storm-winds have not yet become important. East of the lower Mississippi, as far as and in the Appalachians and in the Ohio valley, this is the month with minimum precipitation. New Orleans, 84 mm. (3·3 inches); Chattanooga and Vicksburg, both 66 mm. (2·6 inches); Memphis, Nashville, and Knoxville, all three 69 mm. (2·7 inches); Louisville, 74 mm. (2·9 inches); and Cincinnati 71 mm. (2·8 inches).

Eurasian Area.—The intensity of the Icelandic low-pressure area is greater than in either the preceding or the succeeding month; and most west-coast stations coming within the regime of sea-winds guided to this centre, show a heavier precipitation in October than in September or November.

In Norway this is the case south of the arctic circle—

	September.	October.	November.
	mm. ins.	mm. ins.	mm. ins.
Sannessjöen	116 = 4·6	122 = 4·8	112 = 4·4
Kristiansund	107 = 4·2	130 = 5·1	111 = 4·4
Florö	216 = 8·5	229 = 9·0	201 = 7·9
Bergen	210 = 8·3	223 = 8·8	171 = 6·7
Mandal	145 = 5·7	166 = 6·5	158 = 6·2

East of the mountains, however, the rainfall steadily diminishes, and the region with more than 50 mm. (2 inches) only skirts the Baltic shores.

South of the English channel and the Baltic, at inland as well as at coastal stations, the rainfall has increased. The storm-tracks find their way to the Mediterranean, whose deep salt waters impart to the air above them relatively high temperatures, much moisture, and low pressures. The autumn rains are now abundant over the northern and middle Mediterranean lands. Algeria once more has a considerable precipitation, and even the far Eastern Syrian coastal lands begin to show almost 25 mm. (1 inch) of rain.

The Asiatic high-pressure area is now widespread, although not very high. As much as 25 mm. (1 inch) of rain penetrates as far as the Yenessei from the west. But the land to the east of this is very dry, and the east-coast rainfall is comparatively small and lower everywhere than in September.

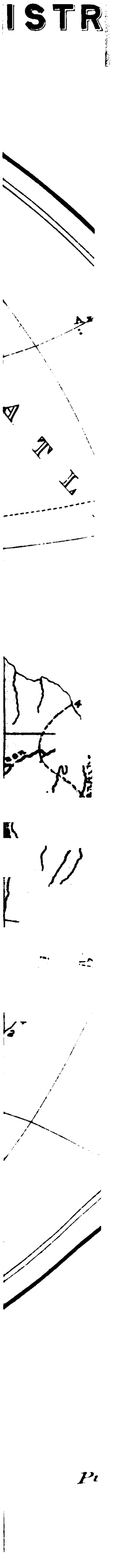
SOUTHERN STORM-WIND SYSTEM.

The rains have almost disappeared from the south-west of Australia and Africa, and have weakened in the west of South America, and also of New Zealand with the approach of summer conditions.

STEADY-WIND SYSTEM.

The sun is at the zenith at noon in the south between 3° 23′ S. and 14°.17′ S. The axis of the highest temperature as well as that of the lowest pressure still lie north of the equator, except in the Australian area, where a region whose temperature is over 32°·2 C. (90° Fahr.) appears. In Africa between the Victoria Nyanza and the Zambesi is another similar region, but it is not nearly so large as the one over the South Sudan.

American Area.—The Mexican rainfall has greatly diminished. At Belize, in British Honduras, the maximum precipitation is recorded in October. From Nicaragua southwards to 40° S., excluding the dry west coast of South America, the rainfall has increased, save at a few stations on the Guiana and North-East Brazilian coasts north of 10° S. There are also two remarkable exceptions to this general rule at Iquitos and San Antonio in the heart of the Amazon basin, which are difficult to explain, except by the shortness of the records at these stations (one year each). Probably longer observations will show that October is not drier in these regions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either September or November. In drawing the isohyets, a progressive advance the isohyetal lines from September to October, and from October to November, been assumed.

Heavy rains fall this month on the Bogotán plateau.

In the east the rainfall is very low and the lower Amazon region is very dry. lly any rain falls in the lower Xingu or at Santarem or Obydos, and only at , where the Yapura joins the main stream, do the rains begin in the middle of month.

Georgetown, Pará and Pernambuco all have their minimum precipitation in tober.

African Area.—The rainfall has become small from Bathurst northwards. In east the rains have ceased at Senaar, but still fall over the Abyssinian high- ds, to the north of which a small depression still remains of the former great low- e area. Rain is reported from Southern Somaliland, especially in the west. rainiest region is the Guinea coast, from Sierra Leone to the Gabun river, and t places where the autumn maximum did not occur in September, have it in tober. The rains now fall abundantly over the Congo basin; but the west stal plain, south of the mouth of that river, is almost rainless, and is still under influence of the South Atlantic anti-cyclone. A strip of coast round Mom- has a considerable precipitation, at some stations over 100 mm. (4 inches); most of the eastern plateau is dry, with a region of slightly higher rainfall the Shiré highlands. The rains have increased in Madagascar except in the treme north-east.

Asia-Australian Area.—Traces of the Old World low-pressure area, which played great a part in ruling the summer weather, are still found in the Indian area reen Ceylon and the north of the Bay of Bengal. But in most places it is not enough to modify the north-east trades which now prevail. At Cuttack the n wind-direction has changed from S. 23° W. to N. 34° E., and the rainfall fallen 267 mm. (10·5 inches) to 145 mm. (5·7 inches). At Madras the wind has ed from S. 36° W. to N. 55° E., and the precipitation from 119 mm. (4·7 to 274 mm. (10·8 inches).

ne north-east trade rains have therefore begun in the south of the Deccan, and , as well as in the eastern half of Ceylon, the precipitation has greatly increased. ll over Ceylon the rainfall is heavier, and the autumnal maximum is reached olombo and in the south-west. The low-pressure area has its greatest effect in region, for we find the wind change at Cochin only in a slight southing from . 76° W. to S. 87° W., and on the other side of the mountains, at Salem, from 63° W. to S. 50° W. The September rainfall at Cochin is 218 mm. (8·6 ches); at Salem, 152 mm. (6·0 inches); that for October at the former, 318 mm. 2·5 inches); at the latter 180 mm. (7·1 inches). This is the second rain- aximum for South-West India as well as for South-West Ceylon.

In Burma there are the same characteristics as in the Deccan. The rainy region s moved southwards. The southerly winds still persist. At Port Blair the mean inds blow S. 1° W.,* at Mergui S. 75° W.,† and the Tenasserim coast is very wet.

Further east the trades are felt, and the exposed coasts of Anam and Formosa d the Philippines receive abundant rains, while the sheltered regions in the lee of rmosa and Hainan are dry, as well as the west sides of these islands and of e Philippines. Again the Yangtse valley has a relatively heavy rainfall, but the nits of this wetter region are quite uncertain.

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* *Indian Weather Review.* Annual Summary, 1896.

† '*Challenger* Report.'

Sumatra and Java have heavy rains on the south-west coasts, but Borneo is wettest in the west. From the centre of Java eastwards very little rain falls, except on the exposed parts of New Guinea.

The summer rains are just beginning in the extreme north of Australia, where Port Darwin has 46 mm. (1·8 inch), the highest rainfall since April.

NOVEMBER.

The northern sub-tropical baric ridge now runs south of 40° N., except in Central Asia, where we find a low-temperature high-pressure system, the reverse of the high-temperature low-pressure condition of summer, and ensuring low instead of high rainfall at most places.

The southern baric ridge is broken up into high-pressure areas over the oceans separated by continental depressions. The maximum line lies somewhat to the south of 30° S.

NORTHERN STORM-WIND SYSTEM.

The isotherms have now their characteristic winter trend and the cold centre has developed in North-East Siberia.

Both the American and Eurasian high-pressure systems have developed in extent and height. While the North Pacific low-pressure area has been elongated until it forms a trough stretching almost from Kamchatka to Sitka, the North Atlantic one has become narrower and shallower, and with two hollows, one between Iceland and Greenland and the other north of Norway.

The rainfall is now typically coastal.

North American Area.—The pressure gradients are now steeper in the north-west, and round Port Simpson and Fort Tongass, where the cyclonic winds are most concentrated, the maximum precipitation is found in November, 351 and 381 mm. (13·8 and 15·0 inches) respectively. Storm-winds bring rains to the coasts as far south as San Francisco. East of the western mountains hardly any rain now falls.

Round the Great Lakes the rainfall is slightly lower than in October. In the east there is little material change. In Labrador it has decreased a little, in New England most of the coastal stations record slightly larger precipitations and the inland ones slightly less. Further south the coastal stations have a lower rainfall, and November is the month of minimum precipitation at most of the Southern Atlantic stations and in Florida.

It is very different in the Mississippi and Ohio valleys. The familiar region of higher rainfall extends up the Mississippi as far as St. Louis. The pressure is more equalized in this region, and the winter storms begin to draw warm moist air from the Mexican gulf.

Eurasian Area.—The weaker condition of the Icelandic depression in November, compared with October and December, gives a slight November minimum to the coastal stations within its influence. We find this in Norway as far south as Bergen, and a glance at the rain-maps of the British Isles reveals the same slight diminution of rainfall in this month. The Baltic coastal region of slightly higher rainfall has narrowed, and in the east of Europe the precipitation has uniformly decreased. The mountain regions of Europe do not now stand out so clearly in the rain-maps.

In the Mediterranean region the rainfall is a little less in the east of Spain, in Italy, and east of the Adriatic. On the other hand, in Sicily, Greece, and the Eastern Mediterranean and Black Sea regions the rainfall has increased, especially in the east.

With the development of the Asiatic high-pressure area there is a decrease in the rainfall. The 25 mm. (1 inch) isohyet no longer runs east of the Urals, beyond which only a few districts of higher rainfall are found. Among these is one on the mountains facing the Turanian plains.

The coastal rains have diminished in the extreme east, except in the west of Japan, where the winter snow and rain brought by the winds from the Sea of Japan have begun to fall.

SOUTHERN STORM-WIND AREA.

The south-western coasts of the three continents receive relatively little rain in November. In South America the isohyets have altered very little. In South Africa and South America the 25 mm. (1 inch) line has almost disappeared. In South-East Africa and South-East Australia, as well as in the same latitudes in the east of South America, the rainfall is increasing on the coast and spreading inland, as the south-east trades move into more southern regions.

In New Zealand the rainfall has diminished in the North island, except at Napier; but the storm-winds bring more abundant rains to the Middle island.

STEADY-WIND SYSTEM.

The sun is zenithal at noon over 14° 36′ S. at the beginning, and over 21° 45′ S. at the end of November.

The steady-wind system has also moved southwards, but more over the southern hemisphere than over the northern, so that it is wider. Its deepest baric hollows lie over the equator in South America and the Malay Archipelago, but another has developed over North-West Australia. Southern prolongations are found over South America and Australia.

American Area.—The northern sub-tropical high-pressure system has moved southwards over the northern part of this area, which is now dry except where the north-east trades strike the coast, where the rainfall remains heavy. This rainfall does not reach far inland. For instance, at Matamoros, near the mouth of the Rio Grande del Norte, the rainfall is 114 mm. (4·5 inches), at Vera Cruz 82 mm. (3·2 inches). Inland on the plateau the precipitation is 34 mm. (1·3 inch) at Saltillo, and only 11 mm. (0·4 inch) at Mexico. At Puerto Barrios it is 421 mm. (16·6 inches), but at Guatemala only 23 mm. (0·9 inch). On the Atlantic side of the Panama isthmus the maximum rainfall is in November, Colon 589 mm. (23·2 inches).

In South America the rainfall has increased everywhere, except in the extreme north, where the rains cease early in the month near the coast, and about the middle of the month over the flat llanos, with the return of the north-east trades. A low-pressure centre has developed round the lower Amazon and over the Guiana coasts, which are struck by the inflowing winds, and the rising air precipitates more than twice the rainfall of October. There is little change on the north-east coast. The heart of the continent is now well watered, and a great area receives more than 200 mm. (8 inches) of rain.

African Area.—With hardly an exception the west coastal rains have greatly diminished on the northern shores of the Gulf of Guinea, but from Gabun to Loanda the spring maximum falls in November. The Congo basin is now exceptionally wet, and, although the area with over 200 mm. (8 inches) of rain cannot be delimited with precision, it probably covers a very large portion of this region.

The eastern plateau between the equator and 5° S. has also as heavy if not a heavier precipitation, the maximum for this vernal wet season.

The coastal lands off Madagascar, and even the whole region between Mozambique and Nyasa, probably have a relatively low rainfall compared to the Shiré highlands, and to places lying further inland.

Madagascar shows an increasing rainfall in the north now that the sun is zenithal at noon over it.

Asia-Australian Area.—In India the north-east trades rule, and only the south-east coast and East Ceylon are well watered. Salem has now an average wind direction of N. 87° E., and its rainfall has fallen to 71 mm. (2·8 inches); whereas, on the east coast itself, at Cuddalore and Negapatam, it has increased from 244 mm. (9·6 inches) and 241 mm. (9·5 inches) respectively, to 348 mm. (13·7 inches) and 381 mm. (15·0 inches). Here, as in most other regions, the normal trade-wind rains do not reach far inland.

Hardly any rain falls on the Tenasserim coast, and at Mergui the winds are now N. 20° E. The Malacca peninsula has a heavier rainfall in the east. Comparing August and September—when the monsoon still reigned—with November, we find that the rainfall near the Strait of Malacca has not altered greatly, being now a little over, instead of a little under, 200 mm. (8 inches); but, on the east side of the peninsula, it has increased from 137 mm. (5·4 inches) in September to 564 mm. (22·2 inches) in November at Pekan in Pahang.

The rainfall of Siam, Anam, China, Formosa, and the Philippines has the same characteristics of a rainy region exposed to the trades, and a very dry region immediately west of the mountain crest. But the rainfall is lower, especially in China, where the pressure is now very high. The rainfall in the Yangtse valley is not half what it was in October.

The precipitation has increased all over the Malay archipelago, where hardly any spot now receives less than 100 mm. (4 inches) of rain, and comparatively few districts less than double that amount. The south coasts of New Guinea are the chief exception to this rule.

The isohyets are further south in Australia, and the rainfall at Port Darwin has more than trebled, being 165 mm. (6·5 inches).

DECEMBER.

There is now a very close approximation to the condition of things with which we began. The axis of the northern sub-tropical baric ridge curves between the Tropic of Cancer in the Pacific and 45° in Central Asia. The southern sub-tropical baric ridge is represented by three high-pressure areas, much reduced in extent and of somewhat less intensity than those of November, and very like those of January.

NORTHERN STORM-WIND SYSTEM.

The temperature has diminished over the continents, and the high-pressure areas have become more definite and important. The North Pacific low-pressure area has widened from north to south, and the North Atlantic low-pressure area has also spread out and deepened with lower pressures than in October. It has its minimum west of Iceland, but from Greenland to the north of Scandinavia there is a pressure lower than 754·4 mm. (29·7 inches).

North American Area.—The axis of high-pressure runs from the Mississippi to the Mackenzie delta, with its highest point over the Colorado plateau. The Pacific extension of this high-pressure system curves southwards from 40° to the Tropic of Cancer, and hence the low-pressure area to the north affects the American coasts much further south than in November. This southward movement is noticeable, not merely in the southern prolongation of the isohyets of 50 mm. (2 inches) to Wilmington in California, but in the increase of rainfall, especially in the region round Vancouver island, where the maximum precipitation for the year is recorded

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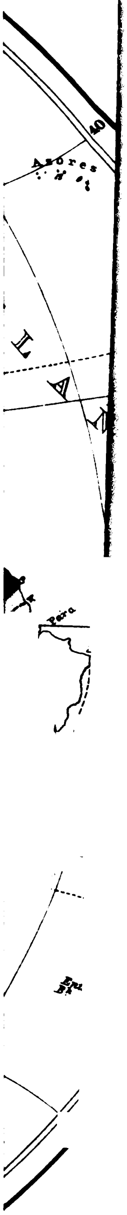

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at most stations. South of this at many coastal stations the December rainfall is little, if any, lower than the January maximum.

Inland the area of low rainfall has increased, and the isohyets approach nearer both to the west and to the east coasts. On the east coast itself the precipitation is lower as far south as Philadelphia, but from Washington southwards the coastal rainfall increases. The 100 mm. (4 inches) Gulf rainy-region does not extend so far north, but its eastern boundary is much further east in December than in November.

Eurasian Area.—With the intensifying of the great Icelandic depression, the west coastal rains in the north-west have once more increased. In Norway they rarely attain the depths recorded in October, but in the British Isles they are heavier than in either of the two foregoing months. The 50 mm. (2 inch) isohyet has disappeared altogether from the Baltic region.

The coastal rainy regions are now most clearly distinguished from drier inland ones. Except near the coast the rainfall is distinctly lower, and even the mountainous regions, such as the Carpathians, have a low and not well-marked rainfall.

The Western Mediterranean region is very much drier, especially in the east of Spain and round Italy, where a small high-pressure area has replaced a low-pressure area. On the other hand, there is a slight increase of rain in the East, at such stations as Constantinople, Smyrna, and those in Crete, Cyprus, Syria, and Egypt. This is the period of heaviest rains in Asia Minor and Cyprus. In Syria it falls a month later.

The Turanian region, with more than 25 mm. (1 inch) of rain, has diminished with the growth of the anti-cyclonic conditions over Asia. The effect of this increase of pressure is also seen in the pushing westwards of this isohyet in Russia, and in the continued diminution of east coast rains. The 25 mm. line hardly appears in East Asia north of Korea, except at the tip of Kamchatka. This month, however, is not that of minimum rainfall, which occurs in January.

It is quite different in Japan, where the winter rains of the west coast are better developed. There is a striking contrast between the precipitation on the east and west shores of the Sea of Japan at this season. In Japan we find Sapporo with a rainfall of 100 mm. (13·9 inches), Niigata with 213 mm. (8·4 inches), and Fushiki with 319 mm. (12·6 inches), the last two maxima; whereas on the mainland St. Olga has 23 mm. (0·9 inch), Vladivostock 5 mm. (0·2 inch), and Fusan 42 mm. (1·7 inch).

SOUTHERN STORM-WIND SYSTEM.

The sub-antarctic low-pressure system has moved northwards where influenced by the lands now more heated by the sun.

The South American isohyets remain the same in the west, but in the east there is both a southern and a western extension of the different isohyets compared with November.

The rains have almost disappeared from the Cape peninsula in Africa, where only about 10 to 25 mm. falls. The isohyets now run almost due north and south except along the south coast, and, except in this southern region, they lie farther west than they did in November. In the extreme east of Cape Colony the rainfall has slightly diminished at most stations, although increases are noted further north. The pressure-gradients are not so steep here in December as they were in November.

Only the southern tip of West Australia receives as much as 25 mm. (1 inch) of rain in December. In the south of South Australia, and in the west of Victoria, the rainfall has also diminished. At the extreme south-east there is no perceptible increase in the rainfall, which, however, becomes much greater as the east coast northwards is followed, both in actual amount and in comparison with the rainfall of November.

In New Zealand the North island receives much the same amount of rain as in November, rather less than more, but the Middle island observations show increases at all stations except Nelson and Christchurch, and maxima along the west coast. The high-pressure area does not affect New Zealand this month, and the sub-antarctic low-pressure belt has moved northwards in this particular region, bringing severer storms with it.

STEADY-WIND SYSTEM.

The sun reaches its southern limit in December, and varies in its zenithal noon position from 21° 54′ S. on the 1st, to more than 23° 27′ S. on the 20th, 21st, and 22nd, and back to 23° 4′ S. on the last day of the year.

The sub-equatorial baric trough lies south of the equator, and has its greatest depths south of the Amazon, near the sources of the Congo, and between North-West Australia and Java, where the two isolated depressions have joined. It now sends extensions southwards across all the continents.

American Area.—In December the high-pressure area has spread southwards. The west and the interior of Mexico receive hardly a drop of rain, *e.g.* Mexico 4 mm. (0·2 inch); and the east coast rainfall, though large when compared with the drought of the plateau, is very little over 50 mm. (2 inches). The maximum rainfall occurs at Greytown (839 mm., or 33·0 inches) and Limon (708 mm., or 27·9 inches), and these are the maxima for the winter half of the year at the two stations.

The rainfall over the Antilles is lower on most islands than in November.

In South America the British Guiana coast has its winter maximum at Georgetown (277 mm., or 10·9 inches), but the lands further east do not reach it until January, when the low-pressure area, which still exists near the mouth of the Amazon, has made its way quite south of the river. The greater part of the continent north of the Tropic of Capricorn now has more than 200 mm. (8 inches) of rain, for the summer monsoon conditions are now fully developed. But the dry region has increased in the extreme north, and still persists, although in a slightly moister condition in the north-east.

African Area.—The west coast rainfall is very much lower at almost all stations north of Damaraland, where there are observations; but probably the maximum rain for the early summer falls on the Benguela-Mossamedes coastal plain in December, for we find on the plateau to the east Caconda has now its maximum precipitation of 241 mm. (9·5 inches).

The northern limit of slight rains is indicated by the six-year mean at Bismarckburg, Togoland, giving 27 mm. (1·1 inch); that for two years at Baliburg, Kamerun, 46 mm. (1·8 inch), compared with 124 mm. (4·9 inches) for November; and at Wadelai on the Nile, 30 mm. (1·2 inch); while only a little further north, at Lado, only 2 mm. (0·1 inch) falls. Rain falls in the south-east of Somaliland, but not in the north. Abyssinia is now rainless, but the Red Sea coasts, on the other hand, have a fair precipitation—Massawa 62 mm. (2·4 inches).

In the east the heavy rainfall has moved southwards to the Tanganyika-Nyasa region. It is impossible to draw any exact line for 200 mm. (8 inches) of rain from the scanty and short period records. At Caconda in the west, and at several stations round Lake Nyasa, the precipitation in December is over 200 mm., and the area between has been coloured to show a rainfall of over this quantity.

The four-year observations at Bolobo on the Congo give 260 mm. (10·2 inches); at Lualuaburg (one year only), 180 mm. (7·1 inches); in the north-east of Tanganyika (two years), 193 mm. (7·6 inches). The northern limit of this rainy region probably follows a line from little north of Bolobo to Tanganyika.

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The summer rains now fall heavily all over Madagascar.

Asia-Australian Area.—In India and Ceylon in December there is an extension of the November movement of dry regions towards the south. The north-east trades still bring rain to the east coast, where it trends from north to south, south of the Krishna. North of this the winds have not enough easting to blow on shore. Even in the south at Madras the mean direction is only N. 25° E., but at Salem it is N. 77° E.

The Ceylon coasts benefit most by the trades, and the maximum precipitation for the year is recorded at Trincomalee, 354 mm. (13·9 inches), and Batticaloa, 396 mm. (15·6 inches), in December. The west coast, on the other hand, receives comparatively little rain.

The rainfall has diminished over the Malacca peninsula in the west, but remains constant in the east and extreme south.

The high-pressure area now extends all over China and Siam, and hardly any rain falls over Eastern Asia, except on the Anamese coast. At Hué it is only one-third of the November precipitation, but at Saigon in the south it is three-fifths. The north-east of Formosa is still wet. The east of the Philippines has heavy rains, but the west coast of Luzon is almost rainless.

Many places in the larger Sunda islands have their maximum precipitation in this month. The axis of heaviest rainfall has moved distinctly southwards.

In South Celebes the wind is more westerly, if we may judge from the returns from Bandjermassin in South-West Borneo, where it alters from E. 88° S. in November to S. 59° W. in December. In this peninsula of Celebes there is a marked difference in the rainfall on the west and east coasts in the two months. In November at Makassar on the east coast it is 183 mm. (7·2 inches), at Balang Nipa 77 mm. (3·0 inches); but in December it has increased to 645 mm. (25·4 inches) at Makassar, but only to 118 mm. (4·6 inches) at Balang Nipa.

The south-west coast of New Guinea remains relatively dry, but the precipitation has increased on the north coast of Kaiser Wilhelm Land and in the Bismarck archipelago, where the winds are blowing towards Australia, over the north of which a low-pressure area is beginning to be formed.

The rainfall at Port Darwin is now 224 mm. (8·8 inches), and the north and east coasts of Australia have a precipitation of over 100 mm. (4 inches).

ANNUAL.

The map of mean annual pressure shows a well-marked equatorial depression bordered on the north and south by two sub-tropical baric regions, on the poleward sides of which are low-pressure areas, well marked over the oceans, less well marked over the continents, passing to a high-pressure area round the north pole, and probably also round the south pole.

The map of mean annual rainfall shows a similar division into seven great areas—the equatorial and north and south temperate rainy belts, separated by the sub-tropical dry belts, and bounded on the polar sides by the polar dry areas. The heavy rainfall further corresponds with low pressure, and the low rainfall with high pressure.

POLAR DRY AREAS.

Observations exist only for parts of the northern polar area whose southern boundary is approximately the arctic circle, within which the annual rainfall is less than 25 mm. (1 inch), except in the west of the continents, especially the Old

World, where the storm-winds and the high temperatures curve to the north-east between Greenland and Europe.

THE TEMPERATE RAIN-BELTS.

The temperate rain-belts lie approximately between the polar circles and 35° of latitude. The rainfall is everywhere over 250 mm. (10 inches), except where the mountains surround far inland places, and arrest all rain-bearing winds from the coasts.

The rainfall is heaviest on the coasts—where the maximum occurs during the winter storms—and diminishes towards the interior—where the maximum occurs in summer. As an example, we may take the following figures from stations practically on the same parallel: Utrecht (13 m. above the sea = 43 feet), 699 mm. (27·5 inches); Berlin (49 m. = 161 feet), 580 mm. (22·8 inches); Voronesh (149 m. = 498 feet), 554 mm. (21·8 inches); and Orenburg (108 m. = 354 feet), 358 mm. (14·1 inches).

The mountains stand out as regions of heavy rainfall in this belt. The region on the lee side of high coastal mountains have usually a low precipitation, *e.g.* Sweden and New Zealand. In the latter islands the heaviest rainfall occurs at Hokitika, on the west coast of the Middle Island, 2845 mm. (112 inches), the lowest at Cape Campbell, in the north-west of the same island, 584 mm. (23 inches).

The average rainfall in the continental regions of the temperate belt is between 250 and 500 mm. (10 to 20 inches), but in the coastal regions, influenced by winter storm-winds, it varies from 500 to 1000 mm. (from 20 to 40 inches) on the flat lands, and from 1000 to 2000, and in some places even over 3000 mm. (40 to 80, and even over 120 inches) in the coastal mountains.

SUB-TROPICAL DRY BELTS.

These occur in the trade-wind areas, and have a rainfall of less than 250 mm. (10 inches). They lie between 35° and 15° of latitude, except where the monsoon winds carry the summer rains nearer the poles. In the Old World this dry area is almost joined to the great dry regions in the heart of the continents. The maximum rainfall occurs in the summer months, when the winds are drawn towards the heart of the continents. The west coasts here are everywhere very dry, and the east coasts are everywhere wet. The annual rainfall along the east coasts varies from 500 mm. to 1000 mm. (20 to 40 inches), and is even greater where there are mountains. These rainy regions form a link between the rainy regions on the east coasts of the temperate lands and the equatorial rainy regions. There is, therefore, a continuity of wet conditions along the east coasts, from the equator polewards almost to the polar circles.

SUB-EQUATORIAL RAIN-BELT.

The sub-equatorial rain-belt lies between 15° N. and S., and the precipitation is almost everywhere over 1000 mm. (40 inches). The exceptions are the dry western coast of South America south of the equator, the São Francisco valley, and Somaliland.

The line of greatest rainfall lies more or less along the geographical equator, and the precipitation diminishes to north and to south. This is what one would expect, as the sun is longest overhead, and the rainfall in these regions is mainly zenithal, and near the equator has two maxima and two minima in the year. The farther we go from the equator one minimum increases and one maximum diminishes in duration, and towards the tropics there is but one rainy and one dry season.

On the Guiana coast, in the mountains of Central America, in the Amazon valley, on the West Coast of Africa, in the mountains of India and China exposed to the monsoons, and in the Malay archipelago there is a rainfall of over 2000 mm. (80 inches). The area with more than 4000 mm. (160 inches) is confined to the mountainous parts of the monsoon regions, such as the Western Ghats, the Khasi hills south of Assam, the Tenessarim coast, the west of Sumatra, and parts of West Africa and Central America.

It will be seen, therefore, that in general the rainfall lines are parallel to the coast where prevalent winds strike them, as in the trade-wind and westerly storm areas, and that elsewhere they tend to lie parallel to the lines of latitude.

SEASONAL DISTRIBUTION.

The plate of curves shows the monthly percentage of rainfall at a selected number of stations, values for each month being first reduced to those for the twelfth part of a year.

America.—The curves for Sitka and San Francisco show different types of west coastal rainfall, with the maximum in winter. Santa Fé, New Mexico, shows a peculiar type of rainfall, which is discussed on pages 36 and 39, where July and August are exceptionally wet. Bismarck, North Dakota, shows the normal type on the plains with the maximum in early summer. Indianapolis shows an early summer maximum also, but has considerable rains in winter, as it is not too far inland to be exempt from the influence of winter storms. At Vicksburg, in Mississippi, the winter storms have still more influence, but at New Orleans there are what might be termed monsoonal rains, making the curve more like that of Indianapolis than of Vicksburg. On the east coast in the south, at Wilmington, South Carolina, the summer rainfall is greatest, but farther north, *e.g.* Boston, the rainfall is fairly uniformly distributed throughout the year.

The Matanzas curve is typical for the Greater Antilles. Vera Cruz, Mexico, and Mazatlan are types of the east coast, interior, and west coast rainfall in Mexico respectively. Georgetown shows a normal curve for a region with a double maximum occurring shortly after the sun is zenithal at noon. At Ceara and Manaos we have the maximum occurring in autumn. At Pernambuco the maximum is later in the year, in the early winter, when the south-east trade-winds are furthest north. The peculiarities of the São Francisco valley have been discussed, and the curve of Santa Anna do Sobradinho is given to illustrate the seasonal distribution of rain in this peculiar region. At Rio de Janeiro summer and winter are the rainy seasons. At Buenos Aires the rainfall is more evenly distributed, but is least in winter.

Bogotá shows the conditions in the north-west. On the west coast at Lima the little rain that falls is precipitated almost entirely between May and October. In Valparaiso the winter maximum is even more marked, but at Ancud, while the maximum occurs in winter, the rainfall is more uniformly distributed throughout the year.

The Old World.—Seathwaite, Moscow, Tomsk, Okhotsk, and Petropavlovsk give typical curves for the rainfall in the west, centre, and east of the northern part of the Old World, the first and last with a winter maximum, the interior stations with a summer maximum. Madrid, Tashkent, and Peking show the seasonal distribution of rain in the intermediate region south of the temperate rainy belt. At the first two little rain falls in summer, at the last little in winter. For the first two the winter storms bring the rain, for Peking the summer monsoons.

Niigati and Tokyo give typical curves for West and East Japan, with maximum winter and summer rainfalls respectively.

Ichang Shanghai, Hongkong, Bangkok and Manila may be compared with Tokyo and Peking as typical curves for eastern monsoonal regions. Rangoon, Calcutta, Simla, and Bombay are similar curves for the Indian monsoonal region, and may be contrasted with Peshawar, where spring and autumn are the rainy seasons, and Quetta, which has one in winter, as well as with Madras and Trincomali, which receive rain with the north-east monsoon. Here also shows the influence of the north-east trades. Colombo has the typical double rainy season of the sub-equatorial regions. Singapore illustrates the constant rains of the equatorial regions. Batavia has the maximum in the summer months.

In Africa Cairo shows the normal distribution of rain in the Eastern Mediterranean with a winter maximum, and Algiers is typical for the Western Bathurst, Lagos and Loanda show the two types of west coast intertropical rain periods with a midsummer maximum. Bolobo shows a more equatorial condition of affairs in the interior of the Congo basin. On the eastern side, Gondar illustrates the heavy summer rains of the Abyssinian highlands. Lado shows similar conditions farther south in the Nile basin, while Natate, in Uganda, gives a picture of the distribution in the equatorial lands of the Victoria Nyanza. Zanzibar shows the type of east coastal rainfall a little south of the equator, and Lauderdale, in the British Central Africa Protectorate, shows a rainy and a dry season round Lake Nyasa. The contrasted conditions of rainfall in the south of Africa are well illustrated by the curves for Cape Town and Durban, the former with a winter, the latter with a summer maximum.

Australasia.—A typical set of Australian curves illustrates the northern, southern, eastern, and western interior rainfalls; and Port Moresby and Finschhafen the conditions north and south of Eastern New Guinea.

GENERAL REMARKS.

In conclusion, a number of general propositions may be deduced from an examination of these twelve maps.

First of all there are seven well-marked bands of high and low rainfall girdling the earth. These are—

(1) Sub-equatorial wet belt.
(2 and 3) Sub-tropical dry belts.
(4 and 5) Temperate wet belts.
(6 and 7) Polar dry caps.

Secondly, these hyetal belts move north and south with the sun;

Thirdly, in equatorial regions there are two wet and two dry seasons every year; and

Fourthly, that most rain falls when the sun is highest at noon, except on the west coasts of temperate lands.

It is now generally admitted that rain can fall steadily, and in considerable quantities, only if there is a steady cooling of the atmosphere, sufficient to neutralize the effect of the increase of temperature due to the liberation of heat when water liquid condenses from water vapour. This is brought about when the air steadily moves from warmer to cooler regions, and the commonest case is that of ascending air. The air may rise from a general convectional movement, such as we find in equatorial regions when the sun is overhead at noon, or from the complicated atmospheric disturbances we call cyclones, or from the interference of a range of

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mountains with the surface winds, deflecting them into higher regions. The liberation of heat, due to condensation of water vapour, aids the ascending current in convectional movements.

The convectional rains are the most important, and occur when the sun is highest in the heavens. Speaking generally, it may be affirmed that the maximum rainfall occurs at most places in the globe when the sun is nearest the zenith at noon—*i.e.* in summer at and beyond the tropics, near the equinoxes at the equator, and at intermediate times between summer and the equinoxes at other inter-tropical stations.

There is an obvious exception to this rule in the case of regions within the polar boundary of the sub-tropical dry belt in summer, but within the equatorial limit of the storm rains in winter.

The temperate belt is essentially that of cyclonic rains; but these are coastal and not continental, as has been pointed out in describing the monthly maps.

Unstable conditions of the atmosphere conduce to rain, and are most common where there are great changes in the surface conditions of the Earth's surface. This happens along the coastal belt everywhere, and also in mountainous regions with great diversity of level. When both coastal and orographical variations are found together, exceptional unstable atmospheric conditions are the rule, and rainfall is abundant, as in the West Scandinavian or Scottish regions. The exceptional cases of the west tropical coasts have been discussed in this paper.

The cyclonic conditions are most intensely developed in the temperate zone in winter, and cyclonic precipitation is then a maximum. Along the exposed coasts this cyclonic rainfall is often greater than that of the summer rains, where the cyclonic element is less.*

The different specific heats of land and water give rise to temperature and pressure-differences over the continents and oceans, of great moment in the question of rainfall. The winter cyclones of the temperate belts cannot penetrate far into the interior of the continents where a great high-pressure system exists. Hence, although the rains may be heavy on the coasts, they do not spread far inland; and the rapidly decreasing temperature gradients from the coast to the interior help to intensify the coastal belt rains. In summer, on the other hand, the low-pressure areas over the continents are the goal of steady if slowly inflowing winds from all sides. The air gradually rises, and the consequent cooling is more than enough to overcome the influence of a rising temperature gradient.

The summer rains are also, in part, the outcome of the greater vapour capacity of the atmosphere, which increases more rapidly than the temperature, so that the same amount of cooling yields a greater rainfall from saturated air at high than at low temperatures.

Much summer rain has its origin in local evaporation. Outside the regions of inland drainage or permanent drought, the rivers carry away a certain proportion of water to the sea. This water must be replaced if the rainfall is to continue. It can only come from the oceans, and hence a steady, even if a very slow and almost imperceptible, current of vapour must flow into the region of summer rains. If not, desert conditions develop.

In this respect it is useful to contrast the effect of the trade-winds under different conditions. The normal trades are usually dry, and pass from regions of low to regions of high temperature, although the temperature gradients may be very slight. The trades travelling from the sea over the land do not cause any rain as long as they are not forced upwards. The flat llanos of South America are dry while the north-east trades rule over them, while the Guiana coasts are wet. In winter, with decreasing temperature gradients and increasing pressure gradients, the trade-winds affect only a narrow strip of mountainous coast-land. But in summer, when the trade-winds are sucked in towards a well-developed low-pressure centre where the air is rising, they must be looked upon as part of the source of the heavy convectional rains that fall when the sun is highest in the heavens. The most graphic example of this is the Asiatic monsoon rains; but monsoonal conditions and rains are common to all the continents, although sometimes slightly masked. It seems to me that this is the simplest explanation of the anomalous conditions in the north-east of South America. The monsoonal conditions do not develop in South America until the sun is well south of the equator, and they remain in force even after it has crossed the line on its northward journey, when the high-pressure conditions begin to develop, which limit the influence of the trades to the coasts. South America and India may profitably be compared, when due allowance is made for their different positions with respect to the equator.

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* It is to be noted, however, that convectional conditions occur in cyclonic areas—the area of cyclonic influence being greater and more stable than the migratory cyclones of temperate regions, while the convectional movements probably are minor cyclonic movements within these great cyclonic areas.

The influence of ocean-currents on rainfall is indirect, through the temperature of the air. The most interesting case of the low rainfall on the tropical west coasts of the continents has already been discussed.

The effects of mountain barriers have also been noted in the description of monthly rainfall. It may be well to point out that the line of maximum elevation is not necessarily the boundary of heavy rains. This may lie on the leeward slopes of the mountains, or at some distance from the edge of a plateau. The air may continue to rise for some distance as it moves beyond the ridge, and the maximum precipitation may even occur beyond this line, and not on the windward slope, as has been shown by Mr. Symons in the case at Seathwaite in the English Lake District. But the rainy area on the lee side of a mountain system is distinctly limited to a very narrow strip, which can be shown only on maps drawn to a very large scale.

The raising of the temperature of the descending air explains the drier regions further to leeward.

Mountain barriers explain the existence of most regions not reached by summer rains. The other dry areas are in the trade-wind areas, and especially in the centre and west of the continents. The parts of such areas furthest from the equator will also be dry if land stretches polewards from them. This territory, however, receives winter rains, and the areas of permanent dry desert are thus confined to the central and western portions of the trade-wind areas, which are not reached either by winter storm-rains or by summer zenithal convectional rains.

The polar caps of low rainfall are areas where the temperature is so low most of the year that little vapour can be held in the atmosphere, and so little can be precipitated out of it. The solid water in such regions, moreover, does not melt or evaporate quickly because of this lowness of temperature.

The deserts of the world are thus divided into two great classes: (1) those due to lack of heat, and so only indirectly to lack of moisture, as the polar areas; (2) and those due to lack of moisture; and this latter class is of two varieties—(*a*) the deserts with permanent dry winds without any mountain barriers, such as the Sahara, and (*b*) the deserts from which moisture is kept out by great mountain ranges, such as Eastern Turkistan.

DATA USED IN DRAWING THE MAPS.*

The sources from which the data used in preparing the maps were obtained are as follows:—

EUROPE.

BRITISH ISLES, SCOTLAND.—Dr. Buchan's maps and paper. ENGLAND, WALES AND IRELAND.—Dr. Buchan's manuscript maps and 'Rainfall of British Isles,' published by the British Meteorological Office, 1897.

CENTRAL AND SOUTH-WESTERN EUROPE.—Dr. Angot's maps and papers.

DENMARK, NORWAY AND SWEDEN.—Means published in the 'Swedish Monthly Reports, 1895.' But revised from the following:—

DENMARK.—Tables in 1882 number of 'Danish Year-Book.'

NORWAY.—Means in 'Nedbør-høiden i Norge' in the *Norsk Teknisk Tidsskrift*, 1893, kindly sent by Prof. Mohn.

SWEDEN.—Dr. Hamberg, maps and paper which he was good enough to send me.

GERMANY AND AUSTRIA.—Revised from publications noted in bibliography.

HUNGARY.—From manuscript tables (herewith published) which the director, Dr. von Konkoly, had prepared by Dr. Oscar Raum, who kindly sent them.

ITALY.—Regions not mapped by Dr. Angot: from values given in the 'Italian Government Year-Book for 1895,' compared with Prof. Millosevich's means.

BALKAN PENINSULA.—Dr. Raulin's paper in the *Meteorologische Zeitschrift.*

RUSSIA.—Dr. Wild's latest means.

ASIA.

RUSSIAN.—Dr. Wild's means.

JAPAN, CHINA, PHILIPPINES AND PARTS OF MALAY ARCHIPELAGO.—From my own manuscript.

SOUTH-WESTERN ASIA.—Partly Dr. Buchan's and my own manuscript.

Note.—The JAPANESE AND PHILIPPINE figures are published here, as well as those for the other lands not given by Dr. Supan.

INDIA.—From the means given in the 'Annual Rainfall of India for 1895,' revised with those for longer periods published in the *Indian Weather Review*, Annual Summary, 1896, an advance copy of which Mr. Eliot was kind enough to supply. Dr. Supan gives a selection of the latter.

DUTCH EAST INDIES.—Means given in the 'Rainfall Report for 1896.' Dr. Supan gives a selection.

BRITISH AND GERMAN POSSESSIONS.—Are manuscript.

AUSTRALASIA AND PACIFIC ISLANDS.

The present maps are revised for the south and east of Australia from those appearing in Bartholomew's 'Physical Atlas,' vol. iii., by using the means for 1881–95 recently calculated by Mr. Waite and myself, which will be published at an early date. The earlier maps were based on the following:—

QUEENSLAND.—The values given here (see tables at end).

NEW SOUTH WALES.—Mr. Russell's diagrammatic tables giving values for each 1° square, as well as the means given in the 'Monthly Meteorological Observations.'

VICTORIA.—The means given in the *Results of Observations in Meteorology*, published quarterly.

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* The exact titles and other particulars will be found in the appended bibliography.

SOUTH AUSTRALIA and NORTHERN TERRITORY.—The means in the annual report on *Meteorological Observations*, 1894.

WESTERN AUSTRALIA.—'Western Australian Year-book, 1894–95.'

AFRICA AND AFRICAN ISLANDS.

SOUTH AFRICA.—Dr. Buchan's maps and papers.

GERMAN SOUTH-WEST AFRICA.—Dr. Dove's tables.

ALGERIA AND TUNISIA.—Dr. Angot's maps.

The rest from manuscript. Dr. Supan publishes all but thirty to thirty-five stations whose returns are for very short periods. A selection of these, and longer means for several stations than are given by Dr. Supan, are printed in the tables at the end.

NORTH POLAR AND NORTH AMERICAN.

Additions to Dr. Supan's list for northern regions, or improvements on it, are given in the tables.

CANADA.—Means given in 'Monthly Weather Review for 1895,' revised with values in 1897. British Columbia, etc., drawn from means published in 1897.

UNITED STATES.—Prof. Harrington's maps for the west and Mr. Henry's for the east. The data quoted in this paper are from the recently published "Bulletin D.," by Mr. Henry, which Prof. Moore was good enough to communicate to me in proof.

Note.—The United States rainfall lines alone are not corrected for the unequal lengths of the months.

MEXICO.—Dr. Hann ('Klimatologie') and manuscript (see tables).

CENTRAL AMERICA.—Prof. Harrington's and Dr. Sapper's tables.

WEST INDIES.—Manuscript. And publications cited in bibliography.

SOUTH AMERICA.

Manuscript. Mainly Sir John Murray's and Dr. Buchan's collections.

Note.—The manuscript employed consists of three collections—

(1) That made by Miss J. H. Buchan for Sir John Murray of the *Challenger*, consisting mainly of returns from all island and coastal stations.

(2) Dr. Buchan's manuscript. In some cases with recently calculated means.

(3) My own collection of means obtained from the *Meteorologische Zeitschrift*, the *Quarterly Journal* of the Royal Meteorological Society, and all manner of official publications since 1890, in addition to numerous averages calculated from the monthly and annual returns of different services and societies. (A complete list of such publications will appear in Bartholomew's 'Physical Atlas,' vol. iii., "Meteorology.")

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No.	Station.	Length of Period.	Dates of Period.	Lat.	Long.	Alt.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Notes.
	STRAITS SETTLEMENTS—*contd.*			° ′	° ′	metres.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	
	Seremban, Sungei Ujong	8	1888–1895	—	—	—	4·19	6·09	9·83	11·10	9·15	6·30	4·66	8·46	8·40	9·93	8·12	8·36	94·84	
	Malacca	10	1886–1895	2 10 N.	102 14 E.	12 ft.	2·42	2·92	4·915	4·93	6·375	7·40	7·427	10·18	7·90	10·055	6·828	7·00	77·36	
	Singapore	27	1869–1895	1 16	103 51	—	8·38	5·76	6·78	6·99	7·07	6·69	6·88	8·53	6·98	8·13	10·04	10·33	92·56	Annual Meteorological Report, Straits Settlements, 1895.
							mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	
	Penang	—	—	—	—	—	111	86	119	184	290	197	235	335	461	439	262	138	2857	The above in millimètres.
	Province Wellesley	—	—	—	—	—	118	100	158	224	195	166	155	232	286	387	207	141	2368	
	Taiping, Perak ...	—	—	—	—	—	302	276	316	434	394	191	215	241	267	591	364	344	3935	
	Gopeng, Perak ...	—	—	—	—	—	161	163	200	312	309	193	202	201	228	318	286	300	2873	
	Pangkor Hospital, Dindings	—	—	—	—	—	174	103	94	180	232	120	161	185	230	312	269	200	2267	
	Pekan, Pahang ...	—	—	—	—	—	243	186	364	230	133	143	133	219	138	241	563	555	3147	
	Kwala Lampur, Selangor	—	—	—	—	—	191	172	196	268	244	100	101	189	177	288	246	229	2403	
	Kwala Pilah, Negri Sembilan	—	—	—	—	—	153	62	154	157	136	120	130	116	118	176	209	183	1714	
	Seremban, Sungei Ujong	—	—	—	—	—	106	155	250	282	232	160	118	215	213	252	206	212	2408	
	Malacca	—	—	—	—	—	61	74	125	125	162	188	189	259	201	255	173	178	1965	
	Singapore	—	—	—	—	—	213	146	172	178	180	170	175	217	177	206	255	262	2352	
	JAPAN.																			
	Yezo—																			
	Soya (North) ...	8	1887–1894	45 31 N.	141 55 E.	24	61	53	28	36	46	56	78	90	150	110	109	63	8795	A. J. H. and P. C. W. MS. calculated from Annual Reports.
	Nemuro (East) ...	9	1886–1894	43 20	145 35	26	24	16	64	80	96	94	96	133	142	89	109	71	1014	
	Sapporo (West) ...	9	1886–1894	43 4	141 22	16	65	59	62	63	46	56	77	119	165	93	102	100	1006	
	Hakodate (South)	9	1886–1894	41 46	140 44	3	54	40	66	87	70	99	126	123	192	98	120	76	1151	
	Hondo (*West*)—																			
	Aomori	9	1886–1894	40 51	140 45	4	133	108	72	70	76	87	106	130	158	97	131	152	1320	
	Akita	9	1886–1894	39 42	140 7	10	120	105	111	127	106	159	154	178	175	137	187	173	1730	
	Niigata	9	1886–1894	37 55	139 3	25	208	112	91	106	90	134	136	113	156	143	191	213	1692	
	Fushiki	9	1886–1894	36 47	137 3	4	275	142	129	139	117	138	143	129	173	124	207	319	2033	
	Sakai	9	1886–1894	35 33	133 14	2	196	117	134	146	117	149	158	150	225	185	159	178	1914	
	Akamagaseki or Shimonoseki ...	9	1886–1894	33 58	130 56	48	56	57	102	159	148	230	273	88	171	102	75	72	1533	
	Interior—																			
	Fukushima ...	5⅔	1889–1894	37 45	140 24	62	52	49	89	74	136	130	116	160	209	103	54	53	1225	
	Utsomomiya ...	4	1891–1894	36 34	139 53	125	33	52	105	112	171	190	258	235	210	100	88	32	1584	
	Gifu	9	1886–1894	35 27	136 46	15	60	65	142	229	221	199	217	174	212	151	97	84	1852	
	Kioto	9	1886–1891	35 1	135 46	49	48	61	117	175	160	188	180	138	157	141	94	58	1514	

No.	Station.	Length of Period.	Dates of Period.	Lat.	Long.	Alt.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Notes.
	AFRICA—*contd.* *Marocco—contd.*																			
	Marocco	—	1886, 1887	° ′ 31 45 N.	° ′ 7 32 W.	metres. 530	mm. 30	mm. 31	mm. 33	mm. —	mm. —	mm. —	mm. —	mm. —	mm. 0	mm. 16	mm. 37	mm. 0 ?	mm. —	Jan., Feb., Mar., two years; Sept., Dec., 1 year; M.Z., '95, p. 111.
	Cape Juby ...	5	1883–1888	27 58	12 52 W.	—	17	27	7	6	0	0	1	0	8	16	19	30	131	Dr. Buchan's MS.
	Tropical W. Africa— Luluaburg ...	1½	1885, 1886	5 56 S.	22 50	620	146	148	164	127	95	5	3	61	157	166	231	180	1483	Dr. Buchan's MS.
	Tropical E. Africa— Natete, Mengo, Uganda ...	8	—	—	—	—	ins. 2·37 mm. 60	ins. 4·38 mm. 111	ins. 4·47 mm. 114	ins. 7·66 mm. 195	ins. 5·30 mm. 135	ins. 3·00 mm. 76	ins. 3·17 mm. 81	ins. 2·89 mm. 73	ins. 3·90 mm. 99	ins. 5·24 mm. 133	ins. 3·89 mm. 99	ins. 1·34 mm. 34	ins. 47·61 mm. 1209	Scott Elliot, 'Naturalist in Mid-Africa,' p. 47.
	Lourenço Marquez	2	1876–1878	25 58 S.	32 37 E.	—	148	144	101	23	13	6	8	3	40	37	26	97	646	Dr. Buchan's MS.
	ICELAND.																			
	Grimsey	8	1881–1886 1891, 1892	66 34 N.	18 3 W.	25	17	10	12	11	10	21	38	40	44	35	29	21	282	Danish Aarbog.
	Stykkisholm ...	24	1856–1868 1881–1892	65 5	22 46	11	66	68	43	35	30	42	40	44	70	75	58	67	638	Danish Aarbog, Dr. Buchan.
	Vestmannö	9	1884–1892	63 26	20 18	8	124	100	100	84	59	90	65	91	141	131	121	140	1246	Danish Aarbog.
	Berufjord	12	1881–1892	64 40	14 15	9	126	123	77	79	70	70	63	91	120	122	144	156	1241	
	LABRADOR.																			
	Rama	—	1883–1889	58 53 N.	63 21 W.	—	$25_{(4)}$	$36_{(3)}$	$25_{(4)}$	$39_{(5)}$	$37_{(5)}$	$49_{(6)}$	$40_{(6)}$	$89_{(6)}$	$80_{(6)}$	$60_{(7)}$	$50_{(5)}$	$24_{(6)}$	554	Calculated from means in 'Deutsch. Ubersch. meteor. Beobachtungen.' Note figures in circles = number of years from which mean calculated.
	Hebron	7½	1883–1890	58 12	62 37	—	$27_{(7)}$	$18_{(7)}$	$20_{(7)}$	$25_{(7)}$	$38_{(7)}$	$55_{(7)}$	$62_{(7)}$	$74_{(7)}$	$74_{(8)}$	$47_{(8)}$	$24_{(8)}$	$16_{(8)}$	482	
	Okak	—	1883–1888	57 40	62 5	—	$22_{(2)}$	$12_{(2)}$	$6_{(2)}$	$10_{(2)}$	$17_{(4)}$	$59_{(4)}$	$57_{(5)}$	$68_{(5)}$	$52_{(5)}$	$28_{(5)}$	$9_{(4)}$	$14_{(3)}$	354	
	Nain	—	1883–1890	56 33	61 40	—	$41_{(2)}$	$31_{(2)}$	$39_{(4)}$	$42_{(4)}$	$29_{(4)}$	$47_{(6)}$	$70_{(6)}$	$67_{(4)}$	$46_{(7)}$	$37_{(7)}$	$23_{(4)}$	$29_{(2)}$	501	
	Zoar	—	1883–1890	56 7	61 24	—	—	—	—	—	$39_{(2)}$	$71_{(5)}$	$73_{(6)}$	$59_{(4)}$	$62_{(5)}$	$58_{(6)}$	$54_{(2)}$	—	—	
	Hoffenthal (Hopedale)	2–8	1883–1890	55 27	60 12	—	$15_{(2)}$	$16_{(2)}$	$19_{(2)}$	$39_{(2)}$	$33_{(6)}$	$59_{(7)}$	$70_{(7)}$	$77_{(7)}$	$73_{(8)}$	$52_{(7)}$	$53_{(5)}$	$11_{(5)}$	517	
	ALASKA.																			
	Fort Alexander ...	6	1881–1886	58 54 N.	158 40 W.	12 ft.	ins. 2·84	ins. 1·16	ins. 3·02	ins. 1·61	ins. 2·43	ins. 1·88	ins. 4·13	ins. 4·38	ins. 4·98	ins. 1·99	ins. 2·84	ins. 1·30	ins. 32·56	Dr. Buchan's MS.
	St. Paul, Kodiak Island	1½	1869, 1870	57 47	152 20 W.	6	8·01	3·31	10·60	5·52	5·42	5·63	1·14	3·71	5·94	7·14	6·61	9·90	72 93	"
	Fort Wrangell ...	3	1868–1870 1875–1877	56 16	139 29	16	5·57	7·59	2·40	4·12	3·69	3·47	3·42	3·12	8·61	8·44	7·62	10·00	68·05	"
	Fort Alexander ...	—	—	—	—	—	mm. 72	mm. 29	mm. 77	mm. 41	mm. 62	mm. 48	mm. 105	mm. 111	mm. 126	mm. 51	mm. 72	mm. 33	mm. 828	The above in millimètres.

No.	Station.	Length of Period.	Dates of Period.	Lat.	Long.	Alt.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Notes.
	QUEENSLAND—*contd.*			° ′	° ′	metres.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	
	Geraldton	8	1888–1895	17 32 S.	146 4 E.	—	22·29	23·82	23·82	22·76	15·61	6·30	3·75	5·69	3·86	2·37	10·04	12·85	150·37	
	Burketown	8	1888–1895	17 48	139 34	—	13·18	9·17	4·50	1·62	0·18	0·48	0·04	0·06	0·04	0·16	1·52	4·05	35·05	
	Floraville	8	1883–1895	18 13	139 53	—	10·17	8·55	4·07	1·02	0·34	0·56	0·01	0·08	0·10	0·68	1·68	4·65	31·96	
	Junction Creek ...	8	1888–1895	18 16	144 20	—	9·65	9·76	4·15	2·54	1·34	0·94	0·27	0·50	0·23	0·61	2·37	5·34	37·72	
	Georgetown	8	1888–1895	18 22	143 32	—	8·75	8·20	2·37	2·60	0·76	0·62	0·13	0·58	0·92	0·74	1·99	5·84	33·42	
	Townsville	8	1888–1895	19 15	146 48	—	14·53	16·13	7·87	5·76	2·02	2·23	0·56	0·73	1·01	1·75	2·37	3·70	58·43	
	Camooweal	4	1892–1895	19 57	138 17	—	5·76	3·71	3·12	0·03	0·50	0·44	0·82	0·87	0·13	0·81	1·83	1·24	19·24	
	Hughenden	8	1888–1895	20 51	144 13	—	6·12	4·84	2·28	2·81	0·91	1·14	0·48	0·40	0·50	0·45	1·91	1·71	23·54	
	Mackay	8	1888–1895	21 9	149 13	—	14·88	15·84	12·21	8·00	5·83	3·03	1·54	1·56	2·65	1·85	2·93	7·13	77·47	
	Carandotta	5	1891–1895	21 55	138 49	—	2·11	1·92	2·26	0·58	0·78	0·53	0·57	0·26	0·04	0·55	1·05	0·65	11·42	
	Clermont	8	1888–1895	22 45	147 38	—	5·56	4·26	2·59	2·43	1·66	1·77	0·87	0·96	1·42	1·73	1·60	4·02	28·87	
	Boulia	8	1888–1895	22 55	139 38	—	2·18	1·85	2·00	0·99	0·91	0·77	0·21	0·32	0·51	0·66	0·58	0·72	11·62	
	Rockhampton ...	14	1881–1895	23 24	150 30	—	7·88	7·96	6·36	2·14	1·76	3·00	2·14	0·80	1·74	1·93	2·16	5·15	43·01	1885 are wanting.
	Longreach	3	1893–1895	23 27	144 8	—	1·85	7·14	0·75	1·41	3·04	2·51	1·61	0·51	0·41	0·37	1·28	1·95	22·57	
	Barcaldine	8	1888–1895	23 33	145 17	—	4·99	2·46	3·96	3·17	2·66	1·46	0·49	0·63	0·71	1·01	1·36	1·26	23·24	
	Alice River	6	1890–1895	23 34	145 47	—	5·66	3·33	2·97	2·40	2·45	2·28	1·06	0·77	1·13	1·68	1·20	1·73	26·66	
	Blackhall	8	1888–1895	24 24	145 26	—	7·55	3·68	2·85	2·85	3·95	1·71	1·03	0·82	0·98	1·77	2·07	2·24	31·50	
	Sandy Cape	8	1888–1895	24 41	153 16	—	7·81	9·00	9·97	5·19	4·38	3·60	3·35	2·69	2·36	1·75	2·28	4·78	57·18	
	Jundah	6	1890–1895	24 49	143 2	—	4·15	3·63	2·90	1·89	2·31	1·68	0·23	0·72	0·53	1·06	0·57	1·18	20·77	
	Tambo	8	1888–1895	24 52	146 16	—	3·31	3·13	3·57	2·61	3·58	1·84	0·82	0·76	0·76	2·40	2·43	1·37	26·78	
	Windorah	8	1888–1895	25 26	142 36	—	2·60	1·72	1·80	2·16	2·18	1·26	0·13	0·44	0·51	0·75	1·01	0·77	14·08	Incomplete.
	Mitchell	8	1888–1895	26 32	147 52	—	4·72	3·38	3·72	2·10	2·79	1·79	0·91	0·94	1·41	1·50	2·17	1·89	27·07	
	Roma	8	1888–1895	26 36	148 42	—	5·20	3·99	5·67	2·77	2·52	1·64	1·45	1·16	1·63	1·36	2·11	2·77	32·27	Incomplete.
	Chinchilla	6	1890–1895	26 45	150 47	—	6·22	3·60	4·25	2·76	1·78	2·52	1·31	1·01	1·07	2·80	2·97	4·49	33·66	
	Crohamhurst ...	3	1893–1895	26 50	152 55	—	25·86	38·77	17·24	8·74	2·73	7·44	1·88	3·07	2·48	3·34	3·58	7·24	122·37	
	Caboolture	8	1888–1895	27 6	152 59	—	8·84	9·29	9·37	5·19	2·52	2·86	2·90	1·73	2·06	2·74	3·12	4·92	54·62	
	Brisbane	14	1881–1895	27 28	153 6	—	8·95	7·07	6·65	4·48	3·23	2·48	2·45	2·65	2·44	3·13	4·09	5·07	52·69	1885 wanting.
	Toowoomba ...	8	1888–1895	27 34	151 58	—	7·10	6·40	5·30	4·03	2·41	2·69	1·68	1·45	2·68	2·01	3·70	4·59	44·03	
	Beenleigh	8	1888–1895	27 44	153 15	—	8·54	9·04	10·19	5·62	2·82	2·20	1·93	2·09	2·89	3·36	3·04	4·69	56·40	
	Thargomindah ...	8	1888–1895	27 58	143 43	450 ft.	2·47	1·24	0·92	1·18	2·16	1·06	0·19	0·54	0·67	1·39	0·43	0·44	12·68	
	Bollon	8	1888–1895	28 6	147 29	—	4·08	2·81	3·51	1·70	1·74	1·32	0·63	0·70	1·46	2·28	1·35	1·64	23·25	
	Eulo	8	1888–1895	28 10	144 59	—	2·25	1·36	1·88	1·58	1·55	1·42	0·48	0·94	1·00	1·27	0·95	0·62	15·30	
	Warwick	8	1888–1895	28 12	152 4	—	5·35	4·28	2·75	2·13	1·48	1·92	1·48	1·07	2·22	2·97	2·98	4·00	32·64	
	AFRICA.																			
	Algerian Sahara—						mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	
	Ayata	$4\frac{1}{2}$	1888–1892	33 30 N.	6 0 E.	40	22	14	27	8	7	1	0	0	4	8	3	29	124	M.Z., '93, p. 470.
	Ghardaïa	5	1887–1892	32 35	3 40	520	19	7	15	8	17	1	0	2	4	3	10	28	114	M.Z., '93, p. 471.
	Marocco—																			
	Rabat	$\frac{8}{12}$	1881–1882	—	—	—	19	37	—	—	—	—	0	0	0	43	37	122	—	Dr. Buchan's MS.

No.	Station.	Length of Period.	Dates of Period.	Lat.	Long.	Alt.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Notes.
	Africa—*contd.* *Marocco—contd.* Marocco	—	1886, 1887	° ′ 31 45 N.	° ′ 7 32W.	metres. 530	mm. 30	mm. 31	mm. 33	mm. —	mm. —	mm. —	mm. —	mm. —	mm. 0	mm. 16	mm. 37	mm. 0?	mm. —	Jan., Feb., Mar., two years; Sept., Dec., 1 year; M.Z., '95, p. 111.
	Cape Juby ...	5	1883–1888	27 58	12 52W.	—	17	27	7	6	0	0	1	0	8	16	19	30	131	Dr. Buchan's MS.
	Tropical W. Africa— Luluaburg ...	1¼	1885, 1886	5 56 S.	22 50	620	146	148	164	127	95	5	3	61	157	166	231	180	1483	Dr. Buchan's MS.
	Tropical E. Africa— Natete, Mengo, Uganda ...	8	—	—	—	—	ins. 2·37 mm. 60	ins. 4·38 mm. 111	ins. 4·47 mm. 114	ins. 7·66 mm. 195	ins. 5·30 mm. 135	ins. 3·00 mm. 76	ins. 3·17 mm. 81	ins. 2·89 mm. 73	ins. 3·90 mm. 99	ins. 5·24 mm. 133	ins. 3·89 mm. 99	ins. 1·34 mm. 34	ins. 47·61 mm. 1209	Scott Elliot, 'Naturalist in Mid-Africa,' p. 47.
	Lourenço Marquez	2	1876–1878	25 58 S.	32 37 E.	—	148	144	101	23	13	6	8	3	40	37	26	97	646	Dr. Buchan's MS.
	Iceland.																			
	Grimsey	8	1881–1886 1891, 1892	66 34 N.	18 3W.	25	17	10	12	11	10	21	38	40	44	35	29	21	282	Danish Aarbog.
	Stykkisholm ...	24	1856–1868 1881–1892	65 5	22 46	11	66	68	43	35	30	42	40	44	70	75	58	67	638	Danish Aarbog, Dr. Buchan.
	Vestmannö	9	1884–1892	63 26	20 18	8	124	100	100	84	59	90	65	91	141	131	121	140	1246	Danish Aarbog.
	Berufjord	12	1881–1892	64 40	14 15	9	126	123	77	79	70	70	63	91	120	122	144	156	1241	
	Labrador.																			
	Rama	—	1883–1889	58 53 N.	63 21W.	—	$25_{(4)}$	$36_{(3)}$	$25_{(4)}$	$39_{(5)}$	$37_{(5)}$	$49_{(6)}$	$40_{(6)}$	$89_{(6)}$	$80_{(6)}$	$60_{(7)}$	$50_{(5)}$	$24_{(6)}$	554	Calculated from means in 'Deutsch. Ubersch. meteor. Beobachtungen.' Note figures in circles = number of years from which mean calculated.
	Hebron	7⅓	1883–1890	58 12	62 37	—	$27_{(7)}$	$18_{(7)}$	$20_{(7)}$	$25_{(7)}$	$38_{(7)}$	$55_{(7)}$	$62_{(7)}$	$74_{(7)}$	$74_{(8)}$	$47_{(8)}$	$24_{(8)}$	$16_{(8)}$	482	
	Okak	—	1883–1888	57 40	62 5	—	$22_{(2)}$	$12_{(2)}$	$6_{(2)}$	$10_{(2)}$	$17_{(4)}$	$59_{(4)}$	$57_{(5)}$	$68_{(5)}$	$52_{(5)}$	$28_{(5)}$	$9_{(4)}$	$14_{(3)}$	354	
	Nain	—	1883–1890	56 33	61 40	—	$41_{(2)}$	$31_{(2)}$	$39_{(4)}$	$42_{(4)}$	$29_{(4)}$	$47_{(6)}$	$70_{(6)}$	$67_{(4)}$	$46_{(7)}$	$37_{(7)}$	$23_{(4)}$	$29_{(2)}$	501	
	Zoar	—	1883–1890	56 7	61 24	—	—	—	—	—	$39_{(2)}$	$71_{(5)}$	$73_{(6)}$	$59_{(4)}$	$62_{(5)}$	$58_{(6)}$	$54_{(2)}$	—	—	
	Hoffenthal (Hopedale)	2–8	1883–1890	55 27	60 12	—	$15_{(2)}$	$16_{(2)}$	$19_{(2)}$	$39_{(2)}$	$33_{(6)}$	$59_{(7)}$	$70_{(7)}$	$77_{(7)}$	$73_{(8)}$	$52_{(7)}$	$53_{(5)}$	$11_{(5)}$	517	
	Alaska.																			
	Fort Alexander ...	6	1881–1886	58 54 N.	158 40 W.	12 ft.	ins. 2·84	ins. 1·16	ins. 3·02	ins. 1·61	ins. 2·43	ins. 1·88	ins. 4·13	ins. 4·38	ins. 4·98	ins. 1·99	ins. 2·84	ins. 1·30	ins. 32·56	Dr. Buchan's MS.
	St. Paul, Kodiak Island	1½	1869, 1870	57 47	152 20 W.	6	8·01	3·31	10·60	5·52	5·42	5·63	1·14	3·71	5·94	7·14	6·61	9·90	72 93	„
	Fort Wrangell ...	3	1868–1870 1875–1877	56 16	139 29	16	5·57	7·59	2·40	4·12	3·69	3·47	3·42	3·12	8·61	8·44	7·62	10·00	68·05	„
	Fort Alexander ...	—	—	—	—	—	mm. 72	mm. 29	mm. 77	mm. 41	mm. 62	mm. 48	mm. 105	mm. 111	mm. 126	mm. 51	mm. 72	mm. 33	mm. 828	The above in millimètres.

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